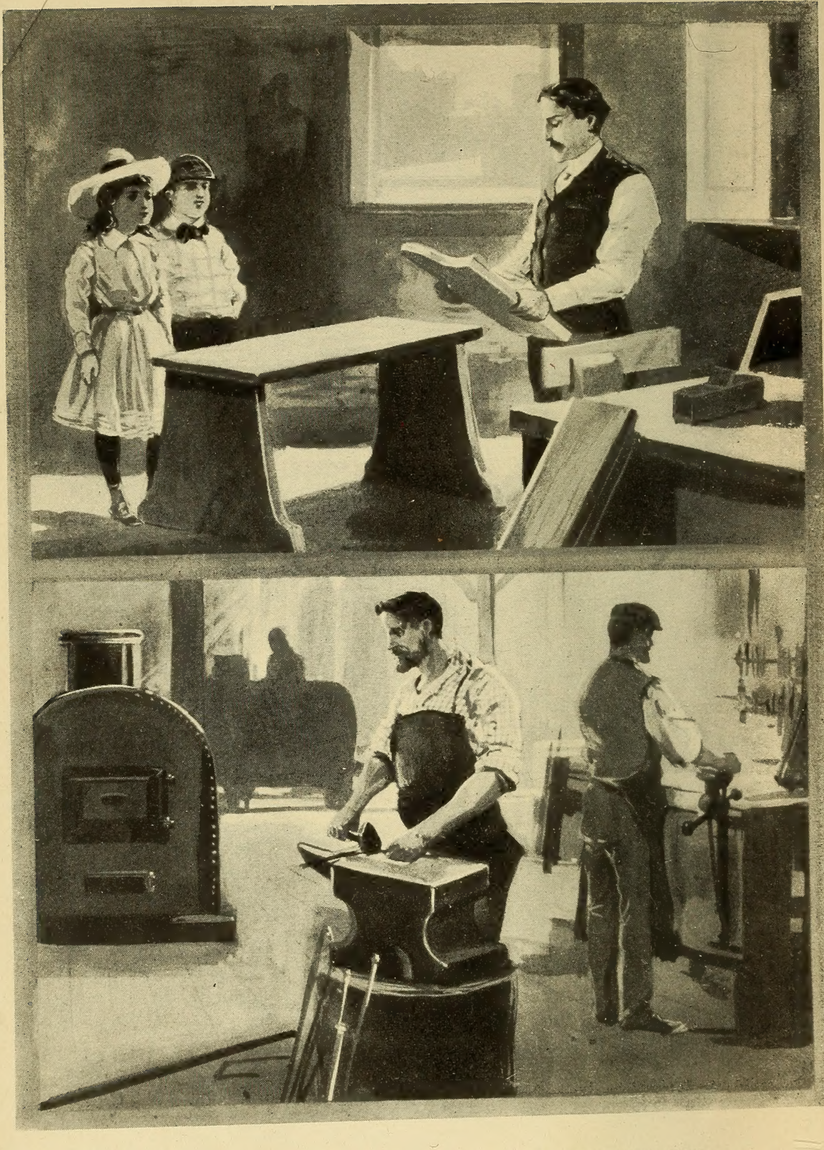
THE NEW CENTURY LIBRARY OF USEFUL KNOWLEDGE



THE HOME ASSISTANT — THE FACTORY HELPER.

THE

HOME AND SHOP MECHANIC

THE USE OF TOOLS
BUILDING RULES AND TABLES
ALL ABOUT BATTERIES, TELEPHONES, ELECTRIC RAILWAYS, ELECTRIC HEATING AND LIGHTING
INFORMATION CONCERNING THE MANUFACTURE OF GLASS, WOODWARE, LEATHER, ARTIFICIAL ICE, CHEMICALS, ETC.
RULES FOR THE INSTRUCTION OF ENGINEERS, FIREMEN, MACHINISTS, MECHANICS AND ARTISANS

Glossary of Technical Terms in Common Use

FORTITER FIDELITER FELICITER

ILLUSTRATED

CHICAGO
LAIRD & LEE, PUBLISHERS

CONTENTS

COTTON INDUSTRY IN NORTH CAROLINA.

In 1886 this state had 80 cotton mills, 4,071 looms and 199,433 spindles. In 1894 this had increased to 156 mills, with 14,908 looms and 700,497 spindles.

In 1897 has been witnessed a wonderful increase in cotton manufacturing, for there are now in this state 1,010 cotton mills, with 1,410 knitting machines, 24,517 looms and 1,044.835 spindles.

The average daily wages paid skilled men (exclusive of machinists, engineers, firemen and superintendents) $1.11; unskilled, 66¼ cents; skilled women, 67½ cents; unskilled, 46 cents, and children 34½ cents, or a general average of 65 cents a day.

The prospect for a rapid extension of the cotton mill industry is excellent, for within the state are water courses with an aggregate of 3,500,000 horse-power, capable of running 140,000,000 spindles.

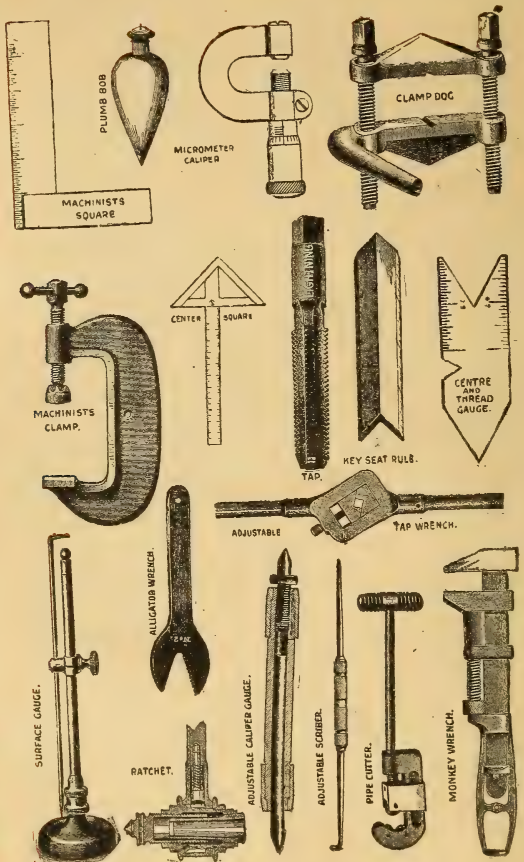
Here is the cotton grown and its transportation to the northern mills saved by its manufacture here. The mills are in excellent condition, and some are declaring as high as 15 per cent. dividend on the capital invested.

MECHANICS' COMPLETE LIBRARY

RULE TO TEMPER TOOLS USED DAILY.

To temper flat, cape or side chisels, and common flat drills, put the tool to be tempered in the fire and heat slowly to a cherry-red color, about four inches from the point. Then take it out and put it in the water, point first, about three or four inches, then draw it back quick about an inch from the point, and leave it so until the water will barely dry on the chisel, then take it out, polish it with a piece of sand stone, and let the heat that is left in the body of the tool force its way towards the point; it will be noticed immediately in the change of color. The color of temper for chisels to cut cast iron should be dark straw, turning to a blue. The temper of chisels to cut wrought iron or steel should be plunged into water after the dark straw color has disappeared and the blue begins to show itself, and left in the water to cool off. In some cases, where the tool is too cold and the temper will not draw, put the tool in and out of the fire often, until the temper shows itself, then cool immediately. If the temper gets to the point of the tool before it is polished, it will have to be heated over again. The above rule answers for lathe, planer and shaper tools as well.

Taps, dies, reamers and twist drills should be tempered in oil. After being heated to a cherry red all over equally, drop the tool into a bucket of oil (plumb) and leave it there until cold; then take it out and brighten it with emery cloth; be careful not to drop it, because it is brittle and liable to break. To draw the temper of taps, reamers and twist drills, heat a heavy ring red hot and enter the tool centrally in the ring, so the heat will be equal from all sides. The hole in the ring should be about three times the diameter of the tool. An old pulley hub would be about right. The color for reamers, taps and twist drills



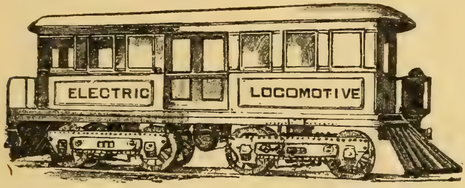
TOOLS IN COMMON USE.

should be dark straw, turning to a blue near the shank; where the color is changing too fast, drop a little water on it; after the right color is obtained, cool off in water. To draw the temper in dies after being cooled in oil, set them (the threads up) on a piece of red-hot iron and draw temper the same color as taps.

For tempering a spring, heat it cherry-red and put it in oil; after it is cool, take it out and hold it over the fire until the oil burns off; then put the spring in the oil again, the in the fire; do this three times; after the last time, plunge it into water and cool off.

ELECTRIC LOCOMOTIVES.

The Baldwin and Westinghouse electric engine has solved the problem of a locomotive running 120 miles an hour.



In appearance this new wonder does not betray its qualities. The motors are incased, so that hardly any mechanism is in sight. The electric headlight and the pilot alone disclose its character as a motor car or locomotive.

The locomotive weighs 150,000 lbs. and is 37 feet long over the pilot.

The frame is made of 10-inch rolled steel plate over the entire floor, giving enormous strength to resist blows in collisions, etc.

This frame is carried on two trucks, with all the modern devices of springs, for swinging motion and free movement. The trucks are built very strong and they are of the swiveling type, so they may go around any curve passable for an ordinary freight car.

The geared connection between the axles and the electric motors permits of any gear ratio desired.

The driving wheels may be connected by parallel rods for pulling heavy trains, as such rods would not permit one pair of wheels to slip without the other.

The motors are directly beneath the car floor, between the two trucks, and are "iron-clad" consequent pole motors. They are entirely encased in thin steel shells. so as to be protected from all injury under normal conditions of service.

The armatures are laminated, being made up of thin slotted discs of steel. In the slots the armature wires are placed. The commutators are of the best forged copper with mica insulation. The motors have the highest grade of insulation. Power is furnished by the third-rail system.

At both ends is a controller. The path of the current may be divided so as to pass to both motors independently, or it may be sent through one motor to the other.

The breaking system has some unique features. The compressed air-brake is used. The engineer's valve is of the standard Westinghouse type. When the handle of the brake valve is put at "emergency" pneumatic action breaks the circuit at the same time as it applies the brakes. A special reversing switch acts on the motors. The automatic air pump is driven by electricity, its special motor being directly connected and without gear.

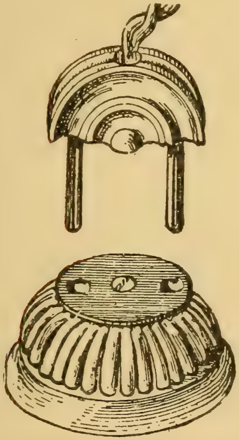
The interior of this locomotive is that of an observation car, and very handsome.

Our 120-miles-an-hour locomotive is ready for us, but we are not quite ready for it. Before we can risk flying across the country at such speed all grade crossings must be abolished and the whole present R. R. signal system must be changed. Signals are now about a mile apart, while the newlocomotive cannot stop within less than one and a half miles of clear way.

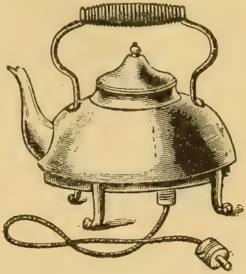
ELECTRICITY FOR HEATING.

To fit heating and cooking utensils for the use of electricity, a thin film of enamel or cement is spread over the outer saucepan, griddle, kettle or heater. Then iron, platinum or other *high resistance* wire is laid zigzag over it, with copper wire connections made to the two ends; and more of the cement or enamel is spread over the wires so as to completely embed them. When enamel is used the apparatus is put in a kiln and burnt on similar to the ordinary iron

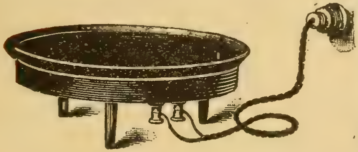
cooking utensils. In both methods the film of enamel or cement insulating the heating wires is put on so thin and is so good a conductor of heat that the heat generated by the electricity is rapidly conveyed to the utensil to be heated.



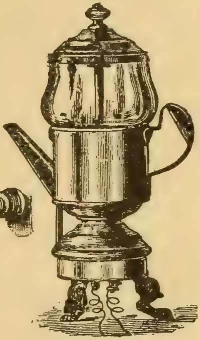
"SHOE" AND PLUG FOR PORTABLE LAMP.



KETTLE.



GRIDDLE.



COFFEE-HEATER.

Electricity can thus be sent through the wires without fear of overheating them. This would not be possible if they were exposed to the air, which does not conduct heat but radiates it.

RECEIPTS FOR GOLD AND SILVER PLATING.

All articles to be plated should be dipped in strong lye or diluted nitric acid, and rinsed off with soft water; then place the article to be plated in the glass that has the solution of either gold or silver, and take a couple of pieces of zinc 1 inch wide, and double to ½-inch wide, by 10 long; let it touch the article to be plated, and you will be surprised at the result. This answers for both.

Take a tablespoonful cyanide of gold and put it in a glass of water, to do gold plating.

Take silver and dissolve in a glass with little nitric acid, when the silver is dissolved then drop hydro-chloric acid in until the white precipitates (silver chloride) ceases to fall; pour off the colored water after it has settled, and add soft water to it, then it is ready for use.

STEEL SHEET PAVEMENTS.

For certain structural purposes the combination of iron and steel with concrete has in various instances been successfully resorted to by builders. According to this method, a steel sheet of light guage is slit perpendicularly in short lengths, say three inches, these slits running in a straight line clear down the sheet, each new one beginning about half an inch from the point where the preceding one ended and the lines being about half an inch apart, this method leaving the sheet of steel cut into long strips of half an inch in width, but connected together every three inches or so. The sheet is now grasped by the same machines on two opposite sides and pulled apart or expanded, so that all the openings appear in diamond shape, the sheet really looking like a wire grating when ready for use. On the earth of the street graded into shape and bedded over with sand is placed the sheet of expanded steel, and over the steel is then laid a layer of concrete, this latter being so tamped into the meshes of the metal as to form a perfect bond. Upon this foundation can be laid asphalt, bituminous rock, basalt block, brick or any kind of surface pavement desired.

UNDERGROUND LONDON.

Underground London contains 3,000 miles of sewers, 34,000 miles of telegraph wires, 4,530 miles of water mains, 3,200 miles of gaspipes, all definitely fixed.

THE STEAM-ENGINE.

The term "Horse-power" is the standard measure of power as applied to steam-engines. This unit of power has been adopted by all manufacturers of steam-engines in all parts of the world.

The term originated with Watts, the so-called inventor of the steam-engine. He demonstrated that a horse could work 8 hours a day continuously, traveling at the rate of 2½ miles an hour, raising a weight of 150 pounds 100 feet high by means of a block and tackle. Reducing this to equivalent terms, a horse could raise 150 pounds at the rate of 220 feet per minute, or 2½ miles an hour, or 33,000 pounds one foot per minute. Thus, a horse-power is the power required to raise 33,000 pounds one foot a minute. There are three kinds of horse-power referred to in connection with engines, "*nominal*," "*indicated*" and "*actual.*"

The *nominal* horse-power is found by multiplying the area of the piston in inches by the average pressure, and multiplying this product by the number of feet the piston travels in feet per minute, then dividing this last product by 33,000. The quotient will be the nominal horse-power of the engine.

The *indicated* horse-power is found by multiplying together the mean effective pressure in the cylinder in pounds per square inch, the area of the piston in square inches and the speed of the piston in feet per minute, and dividing the product by 33,000.

The *actual* horse-power is the indicated horse-power minus the amount expended in overcoming the friction. The following is a general rule for calculating the horse-power of an engine:

RULE.—*Multiply the area of the piston in square inches, the mean pressure of the steam on the piston per square inch, and the velocity of the piston in feet per minute, together, and divide this product by 33,000. The quotient will be the horse-power.*

The *mean pressure* in the cylinder, when cutting off at

¼	stroke,	equals	boiler	pressure	x .597
⅓	"	"	"	"	x .670
⅜	"	"	"	"	x .743
½	"	"	"	"	x .847
⅝	"	"	"	"	x .919
⅔	"	"	"	"	x .937
¾	"	"	"	"	x .966
⅞	"	"	"	"	x .992

TO FIND THE DIAMETER OF A CYLINDER OF AN ENGINE OF A REQUIRED NOMINAL HORSE-POWER.

Divide 5,500 by the velocity of the piston in feet per minute, and multiply the quotient by the required horse-power. The product will be the area of piston in square inches. From this the diameter can be obtained by referring to table of areas of circles.

TO DETERMINE THE EFFECTIVE POWER OF AN ENGINE BY AN INDICATOR.

Multiply the area of the piston in square inches by the average force of the steam in pounds; multiply this product by the velocity of the piston in feet per minute; divide this last product by 33,000, and $\frac{7}{10}$ of the quotient will be the effective power.

The travel in feet of a piston is found by multiplying the distance it travels in inches for *one stroke* by the whole number of strokes per minute. Dividing this product by 12 gives the number of feet the piston travels per minute.

THE SLIDE VALVE.

How to set a slide valve.—Place the crank at the center, and the eccentric at right angles with the crank; then put the valve in the center of its travel, and the rocker plumb at right angles with both cylinder and crank-pin; when this is done, adjust the valve-gear to its proper length, then move the eccentric forward until the valve has the desired amount of lead; make the eccentric fast in this position, and turn the crank around to the other center, and see if the lead is equal; if so, the engine will run all right. In case the lead is not equal, equalize it by moving the eccentric slightly back and forth.

Where the lead is unequal on account of wear, the travel of the valve may be equalized by placing lines of brass or tin behind or in front of the box which connects the valve-rod with the rocker. The "outside lap" means *steam* lap; the "inside lap" means *exhaust* lap.

To compute the stroke of a slide valve.—To twice the lap add twice the width of a steam port in inches, and the sum will give the stroke required.

Half the throw of the valve should be at least equal to the lap on the steam side, added to the breadth of the port. If this breadth does not give the required area of port, the throw of the valve must be increased until the required area is attained.

By referring to the following table, the desired lap may be found if the travel of the valve is known:

Travel of the valve in inches.	The travel of the piston where the steam is cut off.							
	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{5}{32}$	$\frac{1}{2}$	$\frac{7}{12}$	$\frac{2}{3}$	$\frac{3}{4}$	$\frac{10}{12}$
	The required LAP.							
2	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{3}{8}$
$2\frac{1}{2}$	$1\frac{1}{16}$	1	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{9}{16}$	$\frac{1}{2}$	$\frac{7}{16}$
3	$1\frac{1}{4}$	$1\frac{3}{16}$	$1\frac{1}{8}$	1	$\frac{15}{16}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{9}{16}$
$3\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{5}{16}$	$1\frac{3}{16}$	$1\frac{1}{8}$	$1\frac{1}{16}$	1	$\frac{7}{8}$	$\frac{3}{4}$
4	$1\frac{3}{4}$	$1\frac{9}{16}$	$1\frac{7}{16}$	$1\frac{5}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	1	$\frac{13}{16}$
$4\frac{1}{2}$	2	$1\frac{13}{16}$	$1\frac{9}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$\frac{7}{8}$
5	$2\frac{1}{8}$	2	$1\frac{13}{16}$	$1\frac{9}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{4}$	1
$5\frac{1}{2}$	$2\frac{5}{16}$	$2\frac{3}{16}$	2	$1\frac{13}{16}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{8}$
6	$2\frac{1}{2}$	$2\frac{7}{16}$	$2\frac{3}{16}$	2	$1\frac{13}{16}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{3}{16}$

To find how much lap must be given on the steam side of a slide valve to cut off the steam at any given part of the stroke of the piston.—From the length of stroke of the piston subtract the length of the stroke that is to be made before the steam is cut off; divide the remainder by the stroke of the piston, and extract the square root of the quotient; multiply this root by half the throw of the valve; from the product subtract half the lead and the remainder will give the lap required.

Expansion by lap, with a slide valve operated by an eccentric alone, cannot be extended beyond one-third of the stroke of a piston without interfering with the efficient operation of a valve; when the lap is increased, the throw of the eccentric should also be increased.

The lap on the steam side must always be greater than that on the exhaust side, and this difference must be increased the higher the velocity of the piston, for, in fast-running engines, also in locomotives, it is necessary that the exhaust valve should open before the end of the stroke of the piston, so that more time can be allowed for the escape of steam.

"OF COURSE" FOR ENGINEERS.

Of course you will always start your engine slowly, so that the air and water condensation can be expelled from your cold cylinder; then you will gradually bring it to its regular speed.

Of course you will be sure to keep open the drip cock, both in the front and back heads of the cylinder, when the engine is standing still, and never close them until all the water has dripped out.

Of course you will never let in any oil or tallow to your cylinder until it is made hot by the steam.

Of course you will be careful not to put in too much oil at any time, knowing, as you do, that it will be sent to the feed-water and cause your boiler to prime and foam.

Of course you will always *oil up* before starting your engine.

Of course you will always keep your piston and valve-packing in a bag or clean drawer, so as to keep sand, dirt or other grit from becoming attached to it, and so cut or flute the rods.

Of course you will not use *new* waste to wipe up the dirty oil from the stub-ends, crank-pins or cross-head guides, and then use the same waste to polish up the bright and finished work.

Of course you will exercise great care in adjusting the packing in steam-cylinders.

Of course you know that when you generally pack the piston packing, both cylinder and packing are cold, and if they are screwed or wedged in very tight while in this condition that the expansion, when exposed to the heat of the steam, will induce great rigidity.

Of course you understand, if this is so, the oil or lubricating substance cannot enter between the surfaces in contact, and that great friction, heating and cutting will be the result.

Of course you are aware that when packing loses its elasticity it is no good, and should be removed.

Of course you know that piston or valve-rod packing should never be screwed up more than sufficient to prevent it from leaking, and that the softer the packing the longer it will last and the better your engine will run.

Of course you have tried that little trick of screwing the packing up tight when it is first inserted in the boxes, and then slacking the nut off to allow the packing to swell when exposed to the heat of the steam

Of course you will read pages 53, 88, 90, 95, 97 and 103 in this book.

HOW TO ADJUST AND SET CORLISS ENGINE VALVES.

The original crab-claw valve-gear, as used by the inventor, Geo. H. Corliss, has been gradually superseded by the improved half-moon valve-gear, used on the Reynold's engine and other prominent Corliss engine builders.

This difference between the old and new style of valve applies only to the steam-valves, as, in both cases, the exhaust-valves open toward the center of the cylinder.

In the Corliss valve-gear (sometimes called "detachable valve-gear") the action of the steam-valves is positive, the direct action of the working parts of the engine opening them at the proper time, and keeping them open until the connection with the engine is detached or broken, and the hook tripped by the working of the cut-off cams. The steam-valves are closed by vacuum dash-pots (sometimes by springs or weights). The cut-off is automatic and is determined by the requirements of the load on the engine, so that the cut-off cams do not always trip the hook at the same point, as they are moved by the governor.

To those unfamiliar with the Corliss valve-gear, it appears a very complicated affair, yet, in reality it is very simple, and is more easily adjusted than the ordinary slide-valve.

To understand the simplicity of the Corliss valve-gear, the four valves (two steam, two exhaust), must be considered as the four parts—or edges—of the common slide-valve, that is, the working edges of the two steam-valves are equivalent to the two steam edges of the slide-valve, and the working edges of the two exhaust-valves as equivalent to the exhaust edges of the slide-valve.

The principle is the same in the two styles of valves—Corliss and slide—but the difference comes in the adjustment, for the slide-valve is a solid valve, and any adjustment of one part affects the whole, while with the Corliss valve each part is susceptible of an individual and separate adjustment, which can be made, if necessary, while the engine is working, without shutting down. The eccentric works the valves, and are connected with them on the Corliss gear, by means of the wrist plate, carrier-arm, rocker-arm and reach-rod

Besides imparting motion to the valves, the wrist-plate modifies the speed of travel at different parts of the stroke, giving a quick and accelerating speed when opening the steam-valve, and a quick opening and closing of the exhaust-

valve, both steam and exhaust-valves being at their slowest speed when closed.

First, remove the back-leads or back-caps of the four valve-chambers; when this is done the engineer will find guide lines on the ends of the valves, and also on the ends of the valve-chambers. The lines on the steam-valve will coincide with the working edges of the valve, and those on the steam-valve chamber with the working edges of the steam-ports. Guide lines will also be found on the exhaust-valves and ports.

The wrist-plate is located on the valve-gear side of the cylinder, in a central position, between the four valve-chambers.

On the stand, which is bolted to the cylinder, will be found a deeply scribed line, and on the hub of the wrist-plate, three other lines, which show the center of the wrist-plates, and the limits of its travel or throw.

To adjust the valves, the reach-rod which connects the wrist-plates with the rocker-arm, must first be unhooked; next place the wrist-plate in its central position and hold it there.

All the connecting-rods between the steam and exhaust valve-arms and the wrist-plate, are made with right and left hand threads on their opposite ends, and furnished with jamb-nuts, so that the rods can be easily lengthened or shortened by merely slacking the jamb-nuts and turning the rods.

In this manner, set the steam-valves so that for every 10 inch diameter there will be ¼ inch lap, and for every 32 inch diameter ½ inch lap, other intermediate diameters in proportion to these distances.

Set the exhaust-valves for every 10 inch diameter of cylinder with $\frac{1}{16}$ inch lap, and for 32 inch diameter ⅛ inch lap. Double these distances for condensing engines.

The lines on the valves which are nearer the center of the cylinder than the lines on the valve-chambers show the lap on both steam and exhaust valves.

After the valves have thus been adjusted, turn the wrist-plate to the extreme limits of its throw, and adjust the rods connecting the steam-valve arms with the dash-pots, so that, when the rod is down as far as it will go, the square steel block on the valve-arms will just clear the shoulder of the hook. The adjustments of these connecting rods must be properly made, for if too long the steam-valve arm will be bent or broken, and if too short the valve will not open, because the hook will not engage.

Now hook the engine in, loosen the eccentric on the shaft, and turn it over, adjusting the eccentric-rod so that the lines

on the hub of the wrist-plate, which show the limits of its travel and throw, will coincide with the line scribed on the stand.

Place the crank on its dead-center, and turn the eccentric in the direction which the engine is to run, so that the steam-valve will show an opening of $\frac{1}{32}$ to $\frac{1}{8}$ of an inch (depending on the speed at which the engine is to run—the faster the speed the more lead it requires). The line on the valve, which is nearer the end of the cylinder than the line on the valve-chamber, shows the opening required, which is the "lead" or port opening when the engine is on its dead-center.

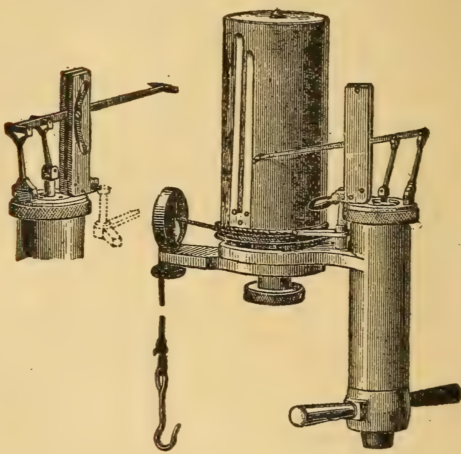
Now secure the eccentric, or the shaft, by tightening the set-screw, and throw the engine over to its other dead-center, carefully noting if the other steam-valve shows the same opening or lead. If it does not, adjust it properly by lengthening or shortening the connecting-rod from the valve-arm to the wrist-plate.

The exhaust-valves are adjusted in the same manner. The directions just given are for the half-moon style of valve-gears, which open *from* the center of the cylinder. In cases of the crab-claw, or any other style which open *toward* the center of the cylinder, the method of adjustment is the same as given above; but, with the difference that the lap on the steam-valves will be shown when the line on the steam-valve is nearer the *end* of the cylinder, and the lead when the line is nearer the *center* of the cylinder than the line on the valve-chamber.

In adjusting the rod connecting the cut-off or tripping cam with the governor, the governor must be at rest, and the wrist-plate at one extreme of its throw or travel.

First adjust the rod connecting with the cut-off cam on the opposite steam-valve so that there will be $\frac{1}{32}$ inch clearance between the cam and the steel on the tail of the hook. Throw the wrist-plate to the other extreme of its travel and adjust the cam for the other steam-valve in the same manner.

Now block the governor up $1\frac{1}{4}$ inch, which will be its average distance when running. Hook the engine in and turn it slowly in its running direction, and mark the distance the cross-head travels from its extreme position of dead-center when the cut-off cam trips the steam-valve. Continue to turn the engine slowly past the other dead-center, and mark the distance of the cross-head from its extreme of travel when the steam-valve drops. If the distance is the same in both cases, the cut-off is equal and the adjustment is correct. If not, adjust one or the other of the rods until this is so.



The steam-engine indicator is now recognized as a highly essential device, with which every engineer should be familiar.

The three main objects for which the indicator can be employed are:

1. To serve as a guide for setting the valves of an engine.
2. To determine the indicated power developed by an engine.
3. To determine, in connection with a feed-water test, showing the actual amount of steam consumed, the economy with which an engine works.

Among the various indicators now on the market, the Tabor Indicator is recognized as the standard, and has been selected to illustrate this article.

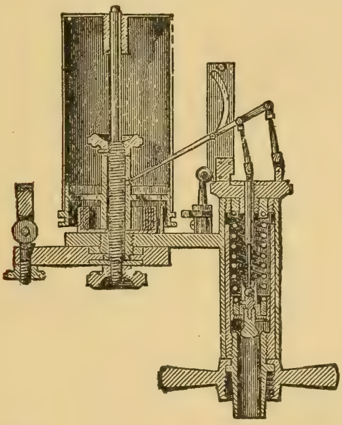
All indicators have one essential plan of construction: There is a *steam-cylinder* and a *paper drum.*

The steam-cylinder is designed to connect with the interior of the engine-cylinder and receive steam whenever the engine receives it. A piston, which is inclosed, communicates motion to a pencil arranged to move in a straight line; the amount of movement being limited by the tension of a spiral spring against which the piston acts.

The *paper drum* is a cylindrical shell mounted on its axis, and is made to turn forward and backward by a motion derived from the cross-head of the engine. A sheet of paper, or *card*, as it is named, is stretched upon the drum, and a pencil is brought to bear upon it. In this manner, the instrument traces upon the paper a line termed the indicator diagram, which is the object sought.

Since the motion of the card is made to coincide with that of the piston of the engine, and the height to which the pencil rises varies according to variations in the force of the steam, the indicator diagram presents a record of the pressure of the steam in the engine cylinder at every point of the stroke.

Sectional View of Standard Instrument



THE METHOD OF INDICATING A STEAM-ENGINE.

There are two things to be done in making arrangements for indicating a steam-engine. *First*, the indicator must be attached to the cylinder; and *second*, means must be provided for giving motion to the paper drum. *To attach the indicator*, a hole is drilled at each end of the cylinder, and tapped for the reception of a half-inch steam-pipe (for the Tabor indicator) to which to connect the indicator cock. In horizontal engines,

the *barrel* of the cylinder should be selected in preference to the heads, as in the position thus secured the indicator can be the most easily operated. Wherever attached, it is important that the pipe should communicate freely with the steam in the cylinder. The hole should not be located, for example, in such a position that it is covered by the piston rings at the end of the stroke. The pipes should be short and free from unnecessary bends.

If a valve is used beneath the cock, it should be of the straght-way type. It is not best to connect the two ends and use a single indicator applied at the center. Errors are produced by the long connections and increased number of bends that this requires, especially at high speeds.

If but one indicator is available; it may be used alternately, first on one end and then on the other; should it be necessary to place the indicator at the center, as convenience in operating generally requires in locomotive work, the errors due to long connections may be reduced by the employment of large pipes and easy bends. For these positions, a three-way cock, to which the indicator cock is attached, is a useful appliance.

In drilling and tapping new holes in a cylinder, care should be taken that the chips do not enter it, unless they can afterward be removed. If no better means can be employed, steam may be admitted while the work is going on, and the chips blown out as fast as formed.

Before attaching the indicator, the cock should be opened to the atmosphere, and the pipes cleared of any loose material that may have lodged in them.

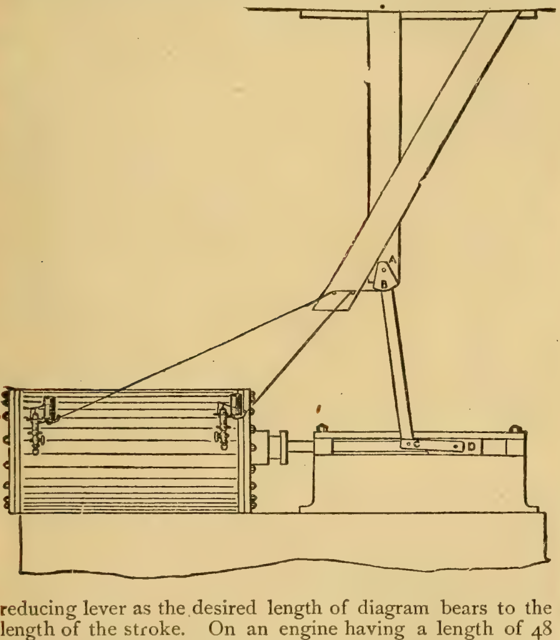
INDICATOR DRIVING RIGGING.

The motion to be given the paper drum is one that coincides, on a reduced scale, with the motion of the piston of the engine. It may be obtained in a variety of ways.

The active instrument here shown, is the reducing lever, A C, which is a strip of pine board 3 or 4 inches wide, and about 1½ times as long as the stroke of the engine.

It is hung by a screw or small bolt to a wooden frame attached overhead. At the lower end a connecting rod, C D, about one-third as long as the stroke, is at one end attached to the lever, and at the other end to a stud screwed into the cross-head, or to an iron clamped to the cross-head by one of the nuts that adjusts the gibs, or to any part of the cross-head that may be conveniently used. The lever A C should stand in a vertical position when the piston is in the middle of the stroke. The connecting rod, C D, when

at that point, should be about as far below a horizontal position as it is above it at either end of the stroke. The cords which drive the paper drums may be attached to a screw inserted in the lever near the point of suspension; but a better plan is to provide a segment, A B, the center of which coincides with the point of suspension, and allow the cords to pass around the circular edge. The distance from edge to center should bear the same proportion to the length of the



reducing lever as the desired length of diagram bears to the length of the stroke. On an engine having a length of 48 inches the lever should be 72 inches, and the connecting rod 16 inches in length, in which case, to obtain a diagram 4 inches long, the radius of the segment should be 6 inches. It is immaterial what the actual length of the diagram is, but 4 inches is a length that is usually satisfactory. It may be reduced to advantage to 3 inches at very high speeds.

The cords should leave segment in a line parallel with the axis of the cylinder. The pulleys over which they pass should incline from a vertical plane and point to the indicators wherever they may be placed.

If the indicators and reducing lever can be placed so as to be in line with each other, the pulleys may be dispensed with, and the cords carried directly from the segment to the instrument, a longer arc being provided for this purpose. The carrier pulley on each indicator should be adjusted so as to point in the direction in which the cord is received.

THE ESSENTIAL FEATURES OF THE INDICATOR DIAGRAM.

The shape of the figure traced upon the indicator card depends altogether upon the manner in which the steam

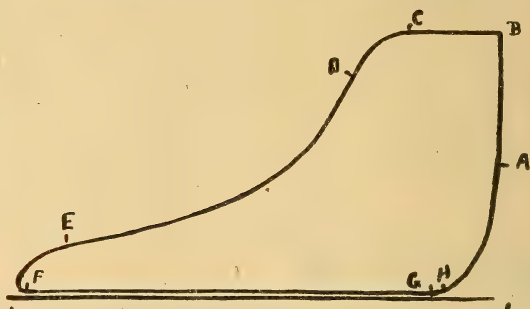


Fig No 1

pressure acts in the cylinder. If the steam be admitted at the beginning, and exhausted at the end, of the stroke, and admission continue from one end to the other, the shape of the diagram is nearly rectangular. If the admission continue through only a part of the stroke, the diagram assumes a shape similar to that of Fig. No. 1. These two representative forms have, in matters of detail, numberless modifications.

Fig. No. 1 has been taken to illustrate the essential features of the indicator diagram, because it exhibits clearly all the operations affected by pressure that commonly take place in the steam engine cylinder.

This diagram shows that the admission of steam commences at A and ends at D; the cut-off commences at C and becomes complete at D; expansion occurs from D to E; the release or

exhaust begins at E and continues to the point H; the compression of the exhaust steam commences at G and ends at the admission point, A.

The line A B is called the *admission line;* B C, the *steam line;* D E, the *expansion line;* F G, the exhaust or *back pressure line* (or, in the case of condensing engines, the vacuum line); H A, the *compression line;* and J I, the *atmospheric line.* The curve which joins two adjacent lines, represents the action of the steam when one operation changes to another and cannot properly be classed with either line.

The point of cut-off, D, lies at the end of admission; the point of release, E, at the beginning of the exhaust, the point of compression, H, at the end of the exhaust. The proportion of the whole length of the diagram borne by the distance of the point D from the admission end, represents the proportion of the stroke completed at the point of cut-off; so also in the case of the point of release, and in that of compression for the uncompleted portion of the stroke. The pressures at the points of cut-off, release and compression are the heights of these various points above the atmospheric line measured on the scale of the spring.

THE USES TO WHICH THE STEAM-ENGINE INDICATOR MAY BE APPLIED.

There are three main objects for the determination of which the indicator diagram may be employed:

First. To serve as a guide in setting the valves of an engine.

Second. To determine the indicated power developed by an engine.

Third. To determine, in connection with a feed-water test showing the actual amount of steam consumed, the economy with which an engine works.

First. Figure No. 1, shows the general features of a well-formed indicator diagram, the attainment of which should be the aim in setting the valves of an engine. The admission of steam is prompt, making the admission line perpendicular to the atmospheric line; the initial pressure is fully maintained up to the point where the steam begins to be cut off; the somewhat early release secures a free exhaust and a uniformly low back pressure, and the exhaust valve closes before the return stroke is completed, providing for compression. These are the first requirements to be met in producing an economical engine.

Derangement of the valve-gearing is revealed in the diagram by tardy admission or release, by low initial pressure or high back pressure, or by absence of compression, either one of which causes an increased consumption of steam for performing the same amount of work.

The angular position of the eccentric controls all the movements of the valves, but improper lengths of the connecting rods which operate them, or improper proportions of lap and lead, are liable to produce some of the faults we mention, as will also a wrong position of the eccentric.

In regulating the exhaust of an engine, the desirability of employing compression should not be overlooked. In the first place, it serves to overcome the momentum of the reciprocating parts and to reduce the strain upon the connections caused by the sudden application of the pressure at admission. In the second place, compression is desirable on the ground of economy in the consumption of steam. It fills the wasteful clearance spaces of the cylinder with exhaust steam, otherwise requiring the expenditure of live steam from the boiler. Compression produces a loss by the increased back pressure which it occasions, but the loss is more than covered by the gain resulting from the reduction of clearance waste. Hypothetically, the greater the amount of exhaust that is utilized by compression the less the consumption of steam. Practically, it is not advisable to compress above the boiler pressure. In a non-condensing automatic cut-off engine with 3 per cent. clearance working at 75 lbs. boiler pressure, cut off at one-fifth of the stroke, and exhausting under a minimum back pressure, the gain produced by compressing up to boiler pressure over working under the same conditions without compression, should be not less than 6 per cent. In a condensing engine, working under similar conditions, the gain should be larger. It should be larger, also, with an earlier cut-off.

The valves being in proper adjustment, the indicator diagram shows whether the pipe and passages for the admission and exhaust of the steam are of sufficient size. In automatic cut-off engines the admission line should be parallel with the atmospheric line, and the initial pressure should not be more than 3 lbs. less than the boiler pressure. The back pressure should not in any engine exceed 1 lb. when the exhaust proceeds directly to the atmosphere. Much can often be learned by applying the indicator to the steam and exhaust pipes, using the same mechanism for driving the paper drum as that used when the indicator is operated at the cylinder.

Before making adjustments upon engines that have been long in use, the operator should ascertain whether a valve which should travel in a different place has worn to a shoulder upon its seat. If changed under such circumstances, loss from leakage may follow, sufficient in amount to neutralize the saving that might otherwise result. This is a matter of much importance.

Second. The indicator is useful in determining the amount of power developed by an engine. The diagram reveals the force of the steam at every point of the stroke. The power is computed from the average amount of this force, which is independent either of the adjustment of the valves, the form of the diagram or of any condition upon which economy depends. The diagram gives what is termed the *indicated* power of an engine, which is the power exerted by the steam. The indicated power consists of the net power delivered and, in addition, that consumed in propelling the engine itself.

In this connection the indicator proves invaluable for measuring the amount of power transmitted to a machine or set of machines, which the engine is employed to drive. The process of measuring power thus used consists in indicating the engine, first with the machinery in operation, and then with the driving belt or shaft thrown off. The difference in the amount or power developed in the two cases is the desired result. Tenants, and those who let power, frequently employ the indicator for this purpose.

Third A third use for the indicator is in connection with a feed-water test, in determining the number of pounds of steam consumed by an engine per indicated horse-power per hour.

This quantity forms a measure of the performance of an engine, and when compared with the performance of the best of its class, shows the economy with which the engine works. The amount of steam consumed is usually found by weighing the feed-water before it is supplied to the boiler, the steam being employed during the test for no other purpose than driving the engine. This requires the erection of a weighing apparatus, the most satisfactory form of which consists of two tanks and platform scales. One tank is placed on the scales, and these are elevated above the second tank, which is of comparatively large size. The water is first drawn into and weighed in the first tank. It is then emptied into the second tank, which serves as a reservoir, and from this it is pumped into the boiler.

A simpler plan may be resorted to, which gives approxi-

mate results. The feed-water is brought to a high point on the glass water-gauge and then shut off, and a test made by observing the rate at which the water boils away. A fall of six inches may be allowed in nearly every case without again feeding. The heights at the beginning and the end of the test being carefully observed, the amount of water evaporated and supplied to the engine is computed from the cubical contents that it occupied in the boilers. A test made in this manner can be repeated a number of times, and the results averaged to insure greater accuracy.

Feed-water tests, made by measuring the water fed to the boiler, are of no value unless leakage of water from the boiler, if any exist, is allowed for. Attention should always be given to this point and the rate of leakage determined by observing the fall of water in the gauge, when no steam is being drawn from the boiler, a constant pressure being maintained.

A portion of the feed-water consumption of an engine may be found without the aid of a feed-water test, by computation from the diagram. Were it not for the losses produced by leakage and cylinder condensation, to which engines are subject the whole amount of feed-water consumed might be determined in this manner. Leakage of steam often occurs and cylinder condensation is inevitable, while the extent to which these losses act is not revealed by any marked effect produced upon the lines of the diagram. The measurement of the consumption of steam by diagram, therefore, cannot be taken to show actual performance without allowing a margin for these losses. Much value, however, often attaches to these computations.

Besides showing the economy of an engine compared with the best of its class, the indicator, by means of the feed-water test, reveals the extent of the losses produced by leakage and cylinder condensation. These losses are represented by that part of the feed-water consumption which remains after deducting the steam computed from the diagram, or *steam accounted for by the indicator*, as it is termed. One of these losses, condensation, is nearly constant for different engines working under similar conditions, and an allowance may be made for its amount. The other, leakage, is variable in different cases, depending upon the condition of the wearing surfaces of valves, piston and cylinder. The fact of the presence of the latter may be detected by a trial under boiler pressure with engine at rest, the leakage being revealed by escape at the indicator cock or exhaust pipe. The amount of

this leakage may be found by computing that part of the loss not covered by condensation. In other words, in the case of leaking engines, when the indicator and feed-water test show that there is more loss than is produced in good practice by condensation, the excess represents the probable amount of loss by leakage. A valuable use for the indicator is thus found in connection with the feed-water test. To make it available in practice, Tables Nos. 1, 2, and 3 are appended, showing the percentages of loss that occur from cylinder condensation. The quantities in Table No. 1 apply to that type of simple engine commonly used, that is, to unjacketed engines having cylinders exceeding twenty inches in diameter; the quantities in Table No. 2 apply to compound engines of the best class having steam jacketed cylinders; and the quantities in Table No. 3 apply to triple expansion engines of the best class, also having steam jacketed cylinders, all supplied with dry but not superheated steam.

TABLE NO. 1.

Percentage of loss by cylinder condensation taken at cut-off in simple engines.

Percentage of stroke completed at cut-off.	Percentage of Feed-water consumption accounted for by the indicator diagram.	Percentage of Feed-water consumption due to cylinder condensation.
5	58	42
10	66	34
15	71	29
20	74	26
30	78	22
40	82	18
50	86	14

TABLE NO. 2.

Percentage of loss by cylinder condensation taken at cut-off in the H. P. cylinder in compound engines.

Percentage of stroke completed at cut-off.	Percentage of Feed-water consumption accounted for by the indicator diagram.	Percentage of Feed-water consumption due to cylinder condensation.
10	74	26
15	76	24
20	78	22
30	82	18
40	85	15
50	88	12

MANNER OF TAKING DIAGRAMS

To take a diagram, a blank card is stretched smoothly upon the paper drum, the ends being held by the spring clips. The driving cord is attached and so adjusted that the motion of the drum is central. The cock is opened to admit steam to the indicator till the parts have become heated, which will be after a half-dozen revolutions. On being shut off, the pencil or marking point is brought into contact with the paper, the stop screw is adjusted, and a fine clear line traced upon the card. This is the atmospheric line. The cock is then opened, and after two or three revolutions the pencil is again applied and the diagram taken. If it is desired to ascertain the condition of the valve adjustment, the pencil needs to be applied only while the engine is making one revolution. But to determine power, it should be applied a longer time, so as to obtain a number of diagrams superposed on the same card. The fluctuations in the admission of steam, produced by governors which do not regulate closely, are so common, that this course should always be followed to obtain average results. The diagram having been traced, and the cock shut, the pencil should be applied lightly to the paper to see that the position of the atmospheric line remains the same. If a new line is traced, it is evidence of error or derangement, and the operations should be repeated on a new card.

It is well to mark upon every card the date, time of day, and end of the cylinder from which it was taken. In adjusting the valves, the boiler pressure should be observed, and the changes that are made before taking a diagram noted on the card for reference. If a series of diagrams is being obtained for power, they should be numbered in order, and the number of revolutions per minute noted, either upon every card, or, if the speed is nearly constant, upon every other one.

If tests are to be made for power used by machines or tenants, a number of diagrams should be obtained under each condition and the results averaged. It is well, in these cases, to mark each card of a set by some letter of the alphabet, and on the first of the set specify the machines in operation at the time.

SPECIAL INSTRUCTIONS.

When accurate work is desired, too much care cannot be exercised in indicating an engine, and a further consideration

of some of the points to be observed will aid the engineer in realizing their importance.

Short steam connections from the cylinder to the indicator are desirable in all cases, and absolutely necessary with high speed engines. Avoid all turns, if possible.

Lubrication of the indicator piston.—The best cylinder oil only should be used for this purpose. The piston should be removed, and the cylinder and piston cleaned and oiled every half-dozen diagrams. The oil contained in the steam *is not sufficient in any case* to lubricate this piston. A lack of lubrication will make a jumping acti on in the movement of the pencil, showing a series of steps, not waves, on the diagram.

Spring to be used.—On slow speed engines the lightest spring that will accommodate the pressure is best, but in high speed engines a heavier spring is necessary for the same pressure, in order to restrict the movement of the pencil bar and connections, and prevent their inertia from distorting the diagram. A waving line is the result of too great a movement of these parts.

The *tension of the spring in paper drum* should in all cases be just sufficient to keep the cord tight; but this means that a greater tension must be used with high than with low speeds, to prevent the inertia of the drum over-winding itself and distorting the diagram; breakage of the cord also frequently results from this cause.

Keeping the cord leading from engine under tension.—This is of no importance with slow running engines, but when indicating high speed engines it is desirable that this cord should always be kept taut, whether the paper drum is running or not. A good plan is to fasten one end of a rubber band to the driving cord four or five inches from the end and attach the other end of the band to the indicator just below the carrier pulley, so that it always keeps a tension on the driving cord; then make a loop in the end of this cord for hooking on the indicator, and the loose end admits of readily connecting and disconnecting without allowing the driving cord to become slack for an instant.

Length of the diagrams.—With slow speeds a length of 4 in. to 4½ in. will show well proportioned diagrams, but as the speeds increase the diagrams must be shortened to avoid the effects of the inertia of the paper drum; and at very high speeds an instrument with the small paper drum should be used. Diagrams at very high speeds should not exceed 2 in. in length, and frequently 1½ in. will give better results.

The pressure of the pencil on the paper should be just sufficient to make a legible mark, and no more; a greater pressure only creates friction, and consequent inaccuracy in the diagram.

Water in the indicator will make a curious but not a useful diagram, and therefore care should be exercised that the indicator is thoroughly heated up before a diagram is taken. Also, if much water is entrained in the steam, it will be necessary to leave the cylinder cocks slightly open while taking diagrams, as otherwise a distorted diagram is almost a certainty.

When taking diagrams from steam-engines, the height of the barometer or pressure of the atmosphere should always be carefully noted. This is necessary when the economy of the engines are to be considered, and it is desirable in all cases to know how much the exhaust pressure is above zero. Even at the sea level the pressure is constantly changing, and there are many engines working at places far above the sea level where the atmospheric pressure is always less, and in some cases very much less, than 14.7 lbs. per square inch, or 29.9 in. of murcury. Care should therefore be exercised in this respect, as there is a tendency among engineers to ignore this fact.

All gauges in ordinary use indicate pressures above the atmosphere; if pressure gauges, or if vacuum gauges the amount below atmospheric pressure; but neither kind show the pressure above zero, or total pressure, and to arrive at this, the pressure of the atmosphere must be added to the gauge pressure in the first case, or the amount of vacuum subtracted from the atmospheric pressure in the second.

THE METHOD OF COMPUTING THE HORSE-POWER OF AN ENGINE FROM THE INDICTOR DIAGRAM.

The work done by the steam in the cylinder of an engine is measured by the product of the force exerted on the piston, into the distance through which the piston moves, and is usually expressed by the term *foot-pounds*. If, for example, a force of 33 lbs. per square inch on a piston having an area of 100 square inches is employed to drive the piston 100 times over a stroke of 4 feet, the work done by the steam amounts to 1,320,000 ft. lbs. The amount of *horse-power* which the steam develops is the foot-pounds of work done in a *minute* divided by 33,000. In the example given, the horse-power developed when 100 strokes are made per *minute* is 1,320,000 divided by 33,000 or 40 H. P.

The force exerted upon the piston is given by the indicator diagram, but as it varies in amount at different points of the stroke, it is necessary to determine the equivalent force which, acting constantly, would produce the same result. This is done by computing from the diagram what is termed the *mean effective pressure.* The product of the mean effective pressure, expressed in pounds per square inch; the area of the cylinder, expressed in square inches; the length of the stroke, expressed in feet; and the number of strokes per minute, which is twice the number of revolutions per minute, gives the number of foot-pounds of work performed per

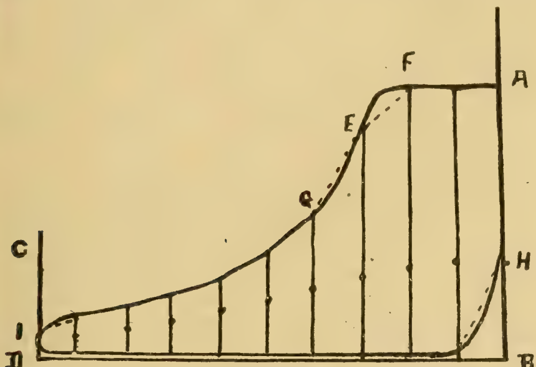


Fig. No 2.

minute. This result, divided by 33,000 gives the amount of horse-power developed.

To compute from the diagram the mean effective pressure, two lines are drawn perpendicular to the atmospheric line, one at each end of the diagram, and the intermediate space divided into 10 equal parts, with a perpendicular at each point of division. A ready method of performing the division is to lay upon the diagram a scale of 10 equal parts, the total length of which is a small amount in excess of the length of the diagram. It is so placed in a diagonal position that the extreme points on the scale lie upon the two outside perpendiculars. The desired points may then be dotted with a sharp pencil opposite the intermediate divisions on the scale. The points where the lines of division cross the

diagram should be dotted; and in locating these points they should be so placed that the area of the figure inclosed by straight lines joining them is exactly equal to the area inclosed by the curved line of the diagram. The proper locations can be readily determined by the eye.

Figure No. 2 shows the extreme perpendiculars A B and C D, the intermediate lines of division, the points of intersection, and those points which require special location, as, for example, the one at E, which is so placed that the area inclosed by the straight lines, E F and E G, is equal to that inclosed by the diagram from F to G.

The determination of the mean effective pressure consists now of finding the average length of the various perpendicular lines included between the points of intersection, measured on the scale of the spring. This may be done by measuring each line with the scale and averaging the results. A better and quicker method is to employ a strip of paper, one of the cards upon which the diagram is traced, if desired, and mark one after another the various distances on its edge, making thereby a mechanical addition, and requiring only a final measurement. The proper course to pursue is to lay the edge of the paper on the first line and mark off the distance, A H, starting from the end of the paper. Transfer the edge of the paper to the last line, and add to the first measurement the distance, I D. Mark off from the end of the paper one-half of the sum of these two distances, and from the middle point continue the addition for the intermediate nine divisions. When all have been marked measure with the scale of the spring, from the end of the paper to the end of the last addition, and divide the result by *ten.* This gives the mean effective pressure. It is essential that *one-half* the sum of the first and last distances be taken, and the sum of this together with the intermediate nine be divided by ten. An erroneous result is obtained by taking the sum of the whole and dividing by eleven.

The engineer who is so fortunate as to possess the knowledge necessary to operate an Indicator will find that his position is not only more secure to him, but his employers will be very apt to show their appreciation in a pecuniary manner.

The use of the Indicator as a *detective*, detecting errors, misadjustments, waste and lost motion in an engine makes it a most necessary adjunct to the engine-room. This fact is becoming more patent every day.

STEAM-BOILERS.

All boilers are divided into three different parts, viz., fire-surface, water-space and steam-room. Each part or division has a distinct and separate duty to perform. The fire-surface includes the furnace and combustion chamber, flues and tubes; the water-space is that part occupied by the water; and the steam-room is the reservoir which holds and supplies the steam necessary to run the engine.

All steam-boilers are either internally or externally fired. Locomotive, marine and portable boilers are internally fired because the fuel is burned in an iron furnace surrounded with a water-jacket or water-leg. Cylinder-flue, double-deck, tubulous and sectional boilers are externally fired, because the fuel is burned in a brick furnace lined with fire-brick.

A perfect steam-boiler should be made of the best material sanctioned by use, and should be simple in construction. It should have a constant and thorough circulation of water throughout the boiler, so as to maintain all parts at one temperature.

It should be provided with a mud-drum to receive all impurities deposited from the water, and the mud-drum should be in a place removed from the action of the fire.

It should have a combustion chamber so arranged that the combustion of the gases commenced in the furnace may be completed before the escape to the chimney.

All parts should be readily accessible for cleaning and repairs.

The boiler should have ample water surface for the disengagement of the steam from the water in order to prevent foaming. It should have a large excess of strength over any legitimate strain. It should be proportioned for the work to be done.

It should have the very best gauges, safety-valves, fusible plugs, and other fixtures.

A *water-tube boiler* should have from 10 to 12 square feet of heating surface for one horse-power; a *tubular boiler* 14 to 18 square feet of heating surface for one horse-power; a *flue-boiler* 8 to 12 square feet of heating surface for one horse-power; a *plain cylinder boiler* should have from 6 to 10 square feet of heating surface for one horse-power; a *locomotive boiler* should have from 12 to 16 square feet of heating surface for one horse-power; a *vertical boiler* should have from 15 to 20 square feet of heating surface for one horse-power.

The following table gives an approximate list of square feet of heating surface per H. P. in different styles of boilers; the

rate of combustion of coal per hour, per square foot of grate surface, required for that rating; the relative economy, and the rapidity of steaming:

TYPE OF BOILER.	Sq. ft. for one H. P.	Coal for each sq. ft.	Relative Economy.	Relative rapidity of Steaming.
Water tube..........	10 to 12	.3	1.00	1.00
Tubular	14 to 18	.25	.91	.50
Flue................	8 to 12	.4	.79	.25
Plain cylinder........	6 to 10	.5	.69	.20
Locomotive..........	12 to 16	.275	.85	.55
Vertical tubular......	15 to 20	.25	.80	.60

HORSE-POWER.

Strictly speaking there is no such thing as "horse-power" to a steam boiler; it is a measure applicable only to dynamic effect. But, as boilers are necessary to drive steam-engines, the same measure applied to steam-engines has come to be universally applied to the boiler. The standard, as fixed by Watt, was one cubic foot of water evaporated per hour from 212° for each horse-power. This was, at that time, the requirement of the best engine in use. Since Watt's time, however, this requirement has been reduced until engines requiring but one-half or one-quarter a cubic foot of water per hour, are in daily use. However, even though the Centennial Exposition in Philadelphia adopted as a standard for tests of boilers *30 pounds water per hour*, evaporated at 70 pounds pressure, from 100° for each horse-power, the general rule, in estimating horse-power of boilers is based on its evaporating one cubic foot of water per horse-power per hour. A cubic foot of water weighs 62½ pounds.

Estimating horse-power of boilers.—One cubic foot, or 62½ pounds, or 6.23 gallons of water evaporated per hour, is equivalent to one horse-power. That is, a boiler that will evaporate ten cubic feet of water, or 625 pounds of water, or 62⅓ gallons of water per hour, is a boiler of 10 horse-power.

An easy approximate rule for estimating the horse-power of a boiler off-hand (if the boiler is a cylinder or flue boiler) is to multiply the length of the boiler by the diameter, in feet, and divide by 6; the quotient will be the nominal horse-power. *Another rule.*—Multiply the *heating surface* in *square yards* by the *fire-grate surface* in *square feet;* the *square root* of the product will be the nominal horse-power.

In estimating the heating surface of a boiler, a vertical or upright surface has only one-half the evaporative value of a horizontal surface above the flame. That is, the sides of a locomotive fire-box are only half as effective per square foot as the flat top of the box. In flues and tubes, the effective surface, measured on the circumference, is 1¼ times the diameter.

To find the fire-grate surface of flue boilers.—Square the nominal horse-power, and divide it by the heating surface in *square yards;* the quotient will be the fire-grate surface in square feet—or, one square foot of fire-grate surface per nominal horse-power.

To find the hea'ing surface of a flue-boiler.—Square the nominal horse-power and divide that by the fire-grate surface in *square feet;* the quotient will be the heating surface in *square yards.*

Capacity of Boiler flue.—One cubic yard of boiler capacity for each nominal horse-power. *Steam room* should be about eight times the contents of the cylinder of the engine supplied with steam by the boiler.

To find the nominal horse-power of a locomotive boiler.—Square the area of the heating surface in *square feet*, and divide by the area of the fire grate in *square feet;* multiply the quotient by .0022; the product will be the nominal horse-power.

To find the area of the heating surface of a locomotive boiler.—Multiply the nominal horse-power by the area of the grate in *square feet;* extract the cube root of the product, and multiply the root by 21.2, the product is the area of the heating surface in *square feet.*

To find the area of the fire-grate surface of a locomotive boiler.—Square the area of the heating surface in square feet, divide it by the number of nominal horse-power, or the cubic feet of water evaporated per hour. The quotient multiplied by .0022 will be the area of the fire-grate surface in *square feet.*

Or, divide the area of the heating surface in *square feet* by 65, the quotient will be the area of the fire-grate in *square feet*, nearly.

Tubular or marine boilers.—Each nominal horse-power requires the evaporation of one cubic foot of water per hour; 12 square feet of heating surface, only three-fourths of the whole tube-surface being taken as effective; and 30 square inches of fire-grate per nominal horse-power. The sectional area of the tubes to be about one-sixth of the fire-grate.

PROPORTIONS OF CYLINDRICAL TUBULAR BOILERS.

No. of Size.	Horse-power.	Diameter in inches.	Length.	Flues.			Domes.		Thickness of shell in inches.	Thickness of heads in inches.	Length of furnace in feet.	Stack.		Weight of boiler in pounds.	Weight of boiler and fixtures in pounds.
				Number.	Dia. in inches.	Length in feet.	Diameter in inches.	Height in inches.				Diameter in inches	Height in feet.		
1	15	36	8′ 11″	30	3	8	20	20	$\frac{1}{4}$	$\frac{3}{8}$	3′	18	26	2,950	5,350
2	20	36	10′ 11″	30	3	10	20	20	$\frac{1}{4}$	$\frac{3}{8}$	3′ 6″	18	30	3,500	5,900
3	25	42	11′	38	3	10	24	24	$\frac{9}{32}$	$\frac{3}{8}$	3′ 6″	20	30	4,400	7,100
4	30	42	13′	38	3	12	24	24	$\frac{9}{32}$	$\frac{3}{8}$	4′	20	36	5,000	7,800
5	35	44	13′	46	3	12	24	26	$\frac{5}{16}$	$\frac{3}{8}$	4′	22	36	5,500	8,700
6	40	48	13′ 2″	52	3	12	24	28	$\frac{5}{16}$	$\frac{3}{8}$	4′	24	36	6,400	9,900
7	45	50	14′ 2″	52	3	13	30	30	$\frac{5}{16}$	$\frac{3}{8}$	4′	24	36	6,800	10,400
8	50	54	13′ 2″	58	3	12	30	30	$\frac{5}{16}$	$\frac{3}{8}$	4′	26	36	7,600	11,500
9	60	54	16′ 2″	58	3	15	30	30	$\frac{5}{16}$	$\frac{3}{8}$	4′ 6″	26	45	8,550	12,750
10	70	60	15′ 4″	76	3	14	30	30	$\frac{11}{32}$	$\frac{7}{16}$	4′ 6″	28	45	10,000	14,500
11	75	60	16′ 4″	76	3	15	30	30	$\frac{11}{32}$	$\frac{7}{16}$	4′ 6″	28	50	10,500	15,100
12	80	60	17′ 4″	76	3	16	30	36	$\frac{11}{32}$	$\frac{7}{16}$	5′	28	55	11,200	16,100
13	90	66	16′ 5″	100	3	15	36	36	$\frac{3}{8}$	$\frac{7}{16}$	5′	32	55	13,500	19,100
14	100	66	17′ 5″	100	3	16	36	36	$\frac{3}{8}$	$\frac{7}{16}$	5′	32	55	14,200	19,800
15	125	72	17′ 6″	132	3	16	36	36	$\frac{7}{16}$	$\frac{1}{2}$	5′	36	60	17 200	24,000

General rule for all classes of boilers.—Twelve square feet of heating surface and three-fourths square foot of fire-grate per nominal horse-power, are very good proportions.

TEMPERATURE INDICATED BY THE COLOR OF THE FIRE.

To determine the temperature of a furnace fire from the color of the flame:

Faint red	960° F.
Bright red	1,300° F.
Cherry red	1,600° F.
Dull orange	2,000° F.
Bright orange	2,100° F.
White heat	2,400° F.
Brilliant white heat	2,700° F.

RULES FOR SAFETY-VALVES.

1.—*To find the distance from the fulcrum at which a given weight is to be placed on the lever, in order to balance a given pressure in the boiler.*—Multiply the *steam pressure* on the whole area of the safety-valve by the distance of the center of the valve from the center of the fulcrum. Multiply the dead weight of the lever and the valve by half the length of the lever, subtract this product from the first product, and divide the remainder by the given weight, supposed to be a cast-iron ball The quotient is the required distance of the weight from the fulcrum in inches. It is necessary, in order to find the steam pressure on the valve, to multiply the *area* of the valve-seat in inches by the pounds pressure per square inch.

Suppose that the entire pressure of steam on the valve is 24 pounds, that the center of the valve is 2 inches from the center of the fulcrum, and that the weight of the ball is 3 pounds —the first product is $24 \times 2 = 48$; the length of the lever is 16 inches, and the united weight of the lever and valve is 4 pounds; then the second product is $(16 \div 2)\ 8 \times 4 = 32$. Then $48 - 32 = 16$, and $16 \div 3 = 5\frac{1}{3}$ inches, the required distance of the center of the ball from the center of the fulcrum.

2. *To find the weight of the ball to hang onto a given length of lever, in order that the steam may blow off at a given pressure.*—Multiply the whole pressure on the valve by its distance from the fulcrum (center to center); from this product subtract the product of the weight of the lever and valve, multiplied by one-half of the length of the lever; then divide the remainder by the whole length of the lever. The quotient is the weight of the ball in pounds.

For example—The pressure in the boiler is 60 pounds per square inch on the valve, the center of the valve is 2 inches from the fulcrum, the weight of the valve and lever is 10 pounds, and the length of the lever is 14 inches.

Suppose the opening in the boiler to be 2 inches in diameter, then 2 squared = 4: and 4 multiplied by .7854 = 3.1416 square inches, the area of the valve. The whole pressure on the valve is 60 pounds 3.1416 = 188.496 pounds. The distance of the center of the valve from the fulcrum is 2 inches, and 188.496 multiplied by 2 = 376.992. From this product, subtract the product of the weight of the valve and lever (10 pounds) by the half-length of lever, 7 inches (total length of lever 14 inches) or 10 7 = 70. Then 376.992 — 70 = 306.992; and 306.922 divided by the length of the lever, or 14 inches, equals 21.928 pounds, the required length of ball.

To find the pressure on the valve.—Multiply the weight of the ball by the length of the lever; to this product add the product of the weight of the lever and valve by the half-length of lever, and divide the sum by the distance of the valve from the fulcrum. The quotient is the pressure on the valve in pounds. Divide this quotient by the area of the valve in square inches, and the quotient will give the blow-off pressure.

Suppose the ball weighs 21.928 pounds, the length of the lever 14 inches, the weight of the lever and valve 10 pounds, the distance of the valve from the fulcrum 2 inches, then $(21.928 \times 14 = 306.992) + 10 \times 7 = 70 = 376.992$; and $376.992 \div 2 = 188.496$ pounds, the whole pressure on the valve. This pressure divided by 3.1416 square inches, the area of the 2″ valve = 60 pounds, the pressure per square inch on the boiler.

SAFETY VALVE CAPACITY.

A safety valve should be capable of discharging all the steam that the boiler can make with all other outlets shut. The United States regulations call for one-half square inch valve area for each square foot of grates; but where the lift will give an effective area of one-half that due to the diameter of the valve, one-fourth square inch valve area per square foot of grate will answer. They give the following diameters:

Area of Grate, Square Feet.	Diameter of Valve, Inches.	
	Common Valve.	Improved Valve.
5	$1\frac{3}{4}$	$\frac{7}{8}$
6	2	1
7	$2\frac{1}{8}$	1
8	$2\frac{1}{4}$	$1\frac{1}{8}$
9	$2\frac{3}{8}$	$1\frac{1}{8}$
10	$2\frac{1}{2}$	$1\frac{1}{4}$
12	$2\frac{3}{4}$	$1\frac{3}{8}$
14	3	$1\frac{1}{2}$
16	$3\frac{1}{4}$	$1\frac{5}{8}$
18	$3\frac{3}{8}$	$1\frac{3}{4}$
20	$3\frac{5}{8}$	$1\frac{3}{4}$
22	$3\frac{3}{4}$	$1\frac{7}{8}$
24	$3\frac{7}{8}$	2
26	4	2
28	$4\frac{1}{4}$	$2\frac{1}{8}$
30	$4\frac{3}{8}$	$2\frac{1}{4}$
32	$4\frac{1}{2}$	$2\frac{1}{4}$
34	$4\frac{5}{8}$	$2\frac{3}{8}$
36	$4\frac{3}{4}$	$2\frac{3}{8}$

CARE OF BOILERS.

1. *Safety Valves.*—Great care should be exercised to see that these valves are ample in size and in working order. (*See rules for Safety Valves, page 82.*) Overloading or neglect frequently lead to the most disastrous results. Safety-valves should be tried at least once a day to see if they will act properly.

2. *Pressure Gauge.*—The steam-gauge should stand at zero when the pressure is off, and it should show same pressure as the safety valve when the latter is blowing off. If not, then one is wrong, and the gauge should be tested by one known to be correct.

3. *Water Level.*—The first duty of an engineer before starting is to see that the water is at the proper height. Do not rely on glass gauges, floats or water alarms, but try the gauge-cocks.

4. *Gauge-Cocks and Water-Gauges.*—Both must be kept clean. Water-gauges should be blown out frequently, and the glasses and passages to gauge kept clean.

5. *Feed-Pump or Injector.*—These should be kept in per-

fect order, and of ample size. No make of pump can be expected to be continuously reliable without regular and careful attention. It is always safe to have two means of feeding the boiler. Check-valves and self-acting feed-valves should be frequently examined and cleaned. Satisfy yourself that the valve is acting when the feed-pump is at work.

6. *Low Water.*—In case of low water immediately cover the fire with ashes (wet if possible) or any earth that may be at hand. If nothing else is handy use fresh coal. Draw fires as soon as it can be done without increasing the heat. *Neither turn on the feed, start or stop engine, or lift safety-valve until fires are out and the boiler cooled down.*

7. *Blister and Cracks.*—These are liable to occur in the best plate iron or steel. When first indications appears, there must be no delay in having it examined and carefully cared for.

8. *Fusible Plugs.*—When used, must be examined when the boiler is cleaned, and carefully scraped clean on both water and fire sides, or they are liable not to act.

9. *Firing.*—Charge evenly and regularly, a little at a time. Moderately thick fires are most economical, but thin firing must be used when draught is poor. Take care to keep the grates evenly covered, and allow no air-holes in the fire. Be especially careful to lay the coal along the sides and in the corners. All lumps should be broken into the size of a man's fist. With bituminous coal, a "coking fire" (that is, firing in front, and then shoving the coal back when it is coked), gives the best result. Do not "clean" fires oftener than necessary. The cleaning of the fire is best done, in ordinary working, by a "rake," or other tool, working on the under side of the grate, and not by a "slice-bar," driven into the mass of fuel *above* the grates.

10. *Cleaning.*—All heating surfaces must be kept clean, outside and in, or there will be serious waste of fuel. The frequency of cleaning will depend on the nature of the fuel and water. As a rule never allow over one-sixteenth inch scales or soot to collect on surfaces between cleanings. Hand holes should be frequently removed and surfaces examined, particularly in case of a new boiler, until proper intervals between cleanings have been established by experience. Examine mud-drums and remove sediment therefrom.

11. *Hot Water Feed.*—Cold water should never be fed into a boiler if it can be avoided, but when necessary, it should be caused to mix with the heated water before coming in contact with any portion of the boiler.

12. *Foaming.*—When foaming occurs in a boiler, checking the outflow of the steam will usually stop it. If caused by dirty water, blowing down and pumping up will generally cure it. In cases of violent foaming, check the draught and cover the fires.

13. *Air Leaks.*—Be sure that all openings for admission of air to boiler or flue, except through the fire, be carefully stopped. This is often an unsuspected cause of serious waste.

14. *Blowing Off.*—If feed-water is muddy or salt, blow off a portion often, according to the condition of the water. Empty the boiler every week or two, and fill up fresh. When surface blow-cocks are used, they should be often opened for a few minutes at a time. Make sure no water is escaping from the blow-off cock when it is supposed to be closed. Blow-off cocks and check-valves should be examined every time the boiler is cleaned.

15. *Leaks.*—Repair leaks as soon as possible after discovered.

16. *Emptying Boiler.*—Never empty the boiler while the brick-work is hot.

17. *Rapid Firing.*—Don't indulge in rapid firing. Steam should be raised slowly from a cold boiler.

18. *Standing Unused.*—If a boiler is not required for some time, empty and dry it thoroughly. If this is impractical, fill it quite full of water, and put in a quantity of common washing soda.

19. *General Cleanliness.*—All things about the boiler-room should be kept clean and in good order. Negligence tends to waste and decay.

INJECTORS.

In setting up injectors, be careful that all the supply-pipes, steam, water or delivery, have the same diameter (internal diameter) as the hole, nipple, branch, plug, tee, or reducer to which they are attached, and that they are as smooth, direct and straight as possible.

Place a strainer over the end of the supply pipe to keep out chips, dirt, etc., but be careful that the meshes or holes of the strainer will equal in area the area of the supply-pipe.

In piping for steam for the injector, take steam from the highest part of the boiler so as to get dry steam. All pipes should be air and water tight, otherwise the injector will kick back, take air and sputter.

In case the water is not to be lifted, but is fed with a head

from a tank or hydrant, place a stop-cock on the pipe to keep the boiler from being flooded.

A stop-valve should also be placed in the steam-pipe, between the steam-room and the boiler and injector, and a check-valve between the water-space and injector.

PUMPS FOR SUPPLYING BOILERS.

Never use smaller diameters of pipes than are called for in the tables furnished by the manufacturers of the pump, as all makers of pumps know the capacity and work to be done by their pumps and their calculations are correct; however, when long pipes are used it is necessary to increase the diameter to allow for increased friction. Observe this suggestion especially in regard to *suction-pipes*. Use as few elbows, T's, and valves as possible, and run every pipe in as direct a line as practicable; use full, round bends when convenient; use Y's instead of T's when possible. Bends, returns, T's and elbows increase friction more rapidly than length of pipe. *Care should be taken against leaks in the suction-pipe, as a very small leak destroys the effectiveness of the suction of a pump.*

See to it that a full head of water is constantly furnished to pump. To prevent the pump from freezing in cold weather, care should be taken to open the drip-plugs and cocks which are provided for the purpose of draining the pump,

Water at a high temperature cannot be raised any considerable distance by suction. For pumping very hot water, place the supply high enough so that the water will gravitate to the pump.

A large suction-chamber placed on the suction-pipe immediately by the pump is very advantageous, and for pumps running at high speed it is a *necessity*. Keep the stuffing-boxes nicely packed. Ordinary speed to run a pump is not over 100 feet piston travel per minute. For continuous boiler-feeding service about half that speed is recommended. *Take as good care of your pump as you do of your engine.*

SOME USEFUL INFORMATION ABOUT WATER.

Doubling the *diameter* of a pipe increases its capacity *four* times. Friction of liquids increases as the square of velocity.

To find the pressure in square inches of a column of water. —Multiply the height of the column in feet by .434, approximately, every foot elevation is equal to ½ pound pressure per square inch; this allows for ordinary friction.

FRICTION OF WATER IN PIPES.

Friction-loss in Pounds Pressure per square inch, for each 100 feet of length in different size clean Iron Pipes discharging given quantities of water per minute.

Gals. per minute.	SIZES OF PIPES—INSIDE DIAMETER.									
	3/4 In.	1 In.	1 1/4 In.	1 1/2 In.	2 In.	2 1/2 In.	3 In.	4 In.	6 In.	8 In.
5	3.3	0 84	0 31	0 12	.....	......	.....	.....	.....	.....
10	13.0	3.16	1.05	0.47	0.12	......	.....	.....	.....	.....
15	28.7	6.98	2.38	0.97	.....	......	.....	.....	.....	.....
20	50.4	12 3	4.07	1.66	0.42	......	.....	.....	.....	.....
25	78.0	19.0	6.40	2.62	.....	0.21	0.10	.....	.....	.....
30	......	27.5	9.15	3.75	0.91	......	.....	.....	.....	.....
35	......	37.0	12.4	5.05	.....	......	..	.....	.....	....
40	......	48.0	16.1	6.52	1.60	......	.....	.....	.....	....
45	......	....	20.2	8.15	....	......	.....	.....	.....	....
50	......	.....	24.9	10 0	2.44	0.81	0.35	0.09	.....	....
75	......	.....	56.1	22.4	5.32	1.80	0.74	.....	.....	....
100	......	.....	......	39.0	9.46	3.20	1.31	0.33	0.05	....
125	......	.....	......	......	14.9	4.89	1.99	.....	.....	....
150	......	.....	......	......	21.2	7.0	2.85	0.69	0.10	....
175	......	.....	......	......	28.1	9.46	3.85	.....	.....	....
200	......	.....	......	......	37.5	12.47	5.02	1.22	0.17	....
250	......	.....	......	......	.....	19.66	7.76	1.89	0.26	0.07
300	......	.....	......	......	.....	28 06	11.2	2.66	0.37	0.09
350	......	.....	......	......	.....	......	15.2	3.65	0.50	0.12
400	......	.....	......	......	.....	......	19.5	4.73	0.65	0.16
450	......	.....	......	......	.....	......	25.0	6.01	0.81	0.20
500	......	.....	......	......	.....	......	30.8	7.43	0.96	0.25
750	......	.....	......	......	.....	......	.....	.....	2.21	0.53
1000	......	.....	......	......	.....	......	.....	.....	3.88	0.94
1250	......	.....	......	......	.....	......	.....	.....	.....	1.46
1500	......	....	......	......	.....	......	.....	.....	.....	2 09

The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch, so that with a perfect vacuum, it will sustain a column of mercury 29.9 inches, or a column of water 33.9 feet high.

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston travel being the standard of speed), divide the number of gallons by 4, then extract the square root, and the product will be the diameter in inches of the pump cylinder

To find the quantity of water elevated in one minute, running at 100 feet of piston speed per minute, square the diameter of the water-cylinder in inches and multiply by 4. *Example:* Capacity of a 5-inch cylinder is desired. The square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, the number of gallons per minute, nearly.

To find the horse-power necessary to elevate water to a given height: multiply the total weight of the water in pounds, by the height in feet, and divide the product by 33,-000. (An allowance of 25 per cent. should be added for water friction, and a further allowance of 25 per cent. for loss in steam-cylinder.)

The area of the steam piston in square inches, multiplied by the steam pressure, gives the total amount of pressure that can be exerted. The area of the water piston, multiplied by the pressure of water per square inch, gives the resistance. A *margin* must be made between the *power* and *resistance* to *move* the pistons at the required speed—say from 20 to 40 per cent., according to speed and other conditions.

To find the capacity of a cylinder in gallons.—Multiplying the area in inches by the length of stroke in inches, will give the total number of cubic inches; divide this amount by 231 (which is the cubical contents of a United States gallon in inches), and the quotient is the capacity in gallons.

To find the quantity of water that will be discharged through an opening or pipe in the sides or bottom of a pipe, tank, barrel or vessel.—Multiply the area of orifice or hole in square inches by the number corresponding to height of surface above orifice, as per table. The product will be the cubic feet discharged per minute.

Height of surface above Orifice. Feet.	Multiplier.	Height of surface above Orifice. Feet.	Multiplier.	Height of surface above Orifice. Feet.	Multiplier.
1	2.25	18	9.5	40	14.2
2	3.2	20	10.	45	15.1
4	4.5	22	10.5	50	16.
6	5.44	24	11.	60	17.4
8	6.4	26	11.5	70	18.8
10	7.1	28	12.	80	20.1
12	7.8	30	12.3	90	21.3
14	8.4	32	12.7	100	22.5
16	9.	35	13.3		

To find the size of hole necessary to discharge a given quantity of water under a given head.—Divide the cubic feet of water discharged by the number corresponding to height, as per table. The quotient will be the area of orifice required in square inches.

SIZES AND CAPACITIES OF A STANDARD BOILER FEED-PUMP.

Steam Cylinder. Inches.	Water Cylinder. Inches.	Stroke. Inch.	Gallons per Stroke.	Capacity per Minute at Ordinary Speed.	Steam Pipe. Inches.	Exhaust Pipe. Inches.	Suction Pipe. Inches.	Delivery Pipe. Inches.	Floor Space Required. Inches.
2½	1½	3	.023	150 Strokes, 3½ gals.	¼	⅜	½	⅜	17 x 5
3	1¾	3	.031	150 " 4¾ "	¼	⅜	¾	½	18 x 5
3¼	2	4	.05	150 " 7½ "	½	¾	1¼	1	26 x 6
3½	2¼	4	.07	150 " 10½ "	½	¾	1¼	1	28 x 7
4	2½	5	.11	150 " 16½ "	½	¾	1¼	1	31 x 8
5	3¼	7	.25	125 " 31 "	¾	1	2	1½	44 x 13
5½	3¾	7	.34	125 " 42 "	¾	1	2	1½	45 x 14
7	4	7	.39	125 " 49 "	1	1¼	2½	2	45 x 14
7	4½	10	.69	100 " 69 "	1	1¼	3	2½	55 x 16
7½	5	10	.85	100 " 85 "	1	1¼	3	2½	55 x 16
8	5	12	1.02	100 " 102 "	1	1¼	4	4	67 x 19
10	6	12	1.47	100 " 147 "	1¼	1½	4	4	67 x 19
12	7	12	2.00	100 " 200 "	2	2½	5	5	67 x 20
14	8	12	2.61	100 " 261 "	2	2½	5	5	67 x 20
16	10	16	5.44	75 " 408 "	2½	3	6	6	80 x 22
18	12	24	11.75	50 " 588 "	3½	4	8	6	110 x 27
20	14	24	16.00	50 " 800 "	3½	4	10	8	111 x 29

To find the height necessary to discharge a given quantity through a given orifice.—Divide the cubic feet of water discharged by the area of orifice in square inches. The quotient will be the number corresponding to height, as per table.

The above rules represent the actual quantities that will be delivered through a hole cut in the plate; if a short pipe be attached the quantity will be increased, the greatest delivery with a straight pipe being attained with a length equal to four times the diameter of the hole. If a taper pipe be attached the delivery will be still greater, being 1½ times the delivery through the plain orifice.

STEAM FOR HEATING.

In estimating for steam-heating, allow one square foot of boiler surface for each ten square feet of radiating surface. Small boilers should be larger proportionately than large boilers.

Each horse-power of boiler will supply from 250 to 350 feet of 1 inch pipe, or 80 to 120 square feet of radiating surface.

Under ordinary circumstances, one horse-power will heat about as follows:

Brick buildings in blocks........	15,000 to 20,000	cubic feet.
Brick stores in blocks...........	10,000 to 15,000	" "
Brick dwellings, exposed all sides	10,000 to 15,000	" "
Brick mills, shops, etc...........	7,000 to 10,000	" "
Wooden buildings, exposed.......	7,000 to 10,000	" "
Foundries and wooden shops....	6,000 to 10,000	" "

It is, of course, but good workmanship to make *all* the joints steam and water tight, as the slightest leak in a steam-heating system is apt to do considerable damage to furniture, curtains, carpets, etc., if the steam is intended to heat a dwelling. Red or white lead is all right as material to make up joints, but graphite is much better (see page 141). For gaskets there is nothing better than asbestos, and this material is now manufactured into gasket rings cut true to size, making asbestos gaskets not only the best, but furnished in a convenient form which will be highly appreciated by the steam-fitter.

The quality of rubber sheets sold by dealers for gaskets, is sometimes of the poorest order, and rubber in any form, vulcanized or otherwise, is poor stuff to put in contact with steam. Gaskets made of thin lead are good, and first class packing can be made of candle wicking and ordinary resin soap, but asbestos is the best.

THE WESTINGHOUSE AUTOMATIC BRAKE.

The Westinghouse Automatic Brake consists of the following essential parts:

1st. *The steam engine and pump*, which produce the compressed air, the supply of steam being regulated by the pump-governor.

2d. *The main reservoir*, in which the compressed air is stored.

3d. *The engineer's brake-valve*, which regulates the flow of air from the main reservoir into the brake-pipe for releasing the brakes, and from the brake-pipe to the atmosphere for applying the brakes.

4th. *The equalizing-valve*, which is connected to a small reservoir, and permits the escape of air from the main brake-pipe, until the pressure in that pipe throughout the entire train is reduced to the same pressure as that in the small reservoir, thus preventing the release of the forward brakes by the engineer closing the brake-valve too quickly, before the pressure in the rear part of the pipe has had time to become reduced.

5th. *The main brake-pipe*, which leads from the main reservoir to the engineer's brake-valve, and thence along the train, supplying the apparatus on each vehicle with air.

6th. *The auxiliary reservoir*, which takes a supply of air from the main reservoir through the brake-pipe, and stores it for use on its own vehicle.

7th. *The brake-cylinder*, which has its piston-rod attached to the brake-levers in such a manner that, when the piston is forced out by air pressure, the brakes are applied.

8th. *The triple valve*, which connects the brake-pipe to the auxiliary reservoir, and connects the latter to the brake-cylinder, and is operated by a sudden variation of pressure in the brake-pipe (1) so as to admit air from the auxiliary reservoir to the brake-cylinder, which applies the brakes, at the same time cutting off the communication from the brake-pipe to the auxiliary reservoir, or (2) to restore the supply from the brake-pipe to the auxiliary reservoir, at the same time letting the air in the brake-cylinder escape, which releases the brake.

9th. *The couplings*, which are attached to flexible hose and connect the brake-pipe from one vehicle to another.

The automatic action of the brake is due to the construction of the triple valve, the primary parts of which are a piston and a slide-valve. A reduction of pressure in the brake-pipe causes the excess of pressure in the auxiliary reservoir to

force the piston of the triple valve down, moving the slide-valve down so as to allow the air in the auxiliary reservoir to pass directly into the brake-cylinder and apply the brakes. When the pressure in the brake-pipe is again increased above that in the auxiliary reservoir the piston is forced up, moving the slide-valve to its former position, opening communication from the brake-pipe to the auxiliary reservoir and permitting the air in the brake-cylinder to escape, thus releasing the brakes.

Thus it will be seen that *any reduction of pressure in the brake-pipe applies the brakes*, which is the essential feature of the automatic brake. If the engineer wishes to apply the brakes he moves the handle of the engineer's brake-valve to the right, which first closes a valve retaining the pressure in the main reservoir and then permits a portion of the air in the brake-pipe to escape. To release the brakes he turns the handle to its former position, which allows the air in the main reservoir to flow into the brake-pipe, restoring the pressure and releasing the brakes. A valve called the *conductor's valve* is placed in each car, with a cord running the length of the car, and any of the trainmen, by pulling this cord can open the valve, which allows the air to escape from the brake-pipe. In applying the brake in this manner the valve must be held open until the train comes to a stop. Should the train break in two the air in the brake-pipe escapes and the brakes are applied to both sections of the train, and should a hose or pipe burst the brakes are also automatically applied.

The gauge shows the pressure in the main reservoir and brake-pipe when they are connected, and the pressure in the brake-pipe alone when the main reservoir is shut off by the movement of the engineer's brake-valve.

A *stop cock* is placed in each end of the brake-pipe, and is closed before separating the couplings, thus preventing an application of the brakes when cars are uncoupled.

The diagram above the engineer's brake-valve shows the various positions of the handle for applying the brakes with any desired degree of force, for releasing the brakes, and the position in which the handle is to be kept after the brakes have been released.

Following will be found detailed views and descriptions of detached portions of the apparatus; also a full series of instructions for its proper use and maintenance. Too much importance cannot be attached to that portion of the instructions stating that engineers should use care and moderation

in applying the brakes for ordinary stops. By applying them at a fair distance from the station, with moderate force, the train is stopped gently and without inconvenience to the passengers, while if they are thrown on with the utmost force possible, the train is jerked in a manner that is extremely disagreeable to the passengers.

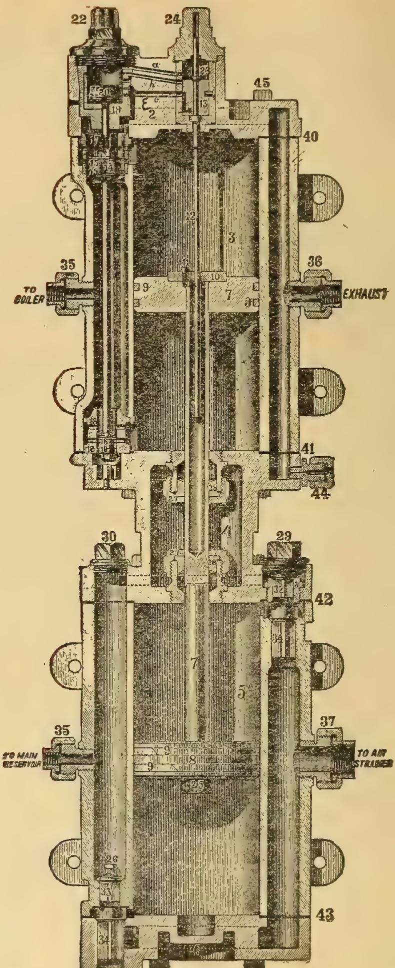
AIR PUMP.

Referring to cut, it will be seen that the steam from the boiler enters the top cylinder between two pistons forming the main valve. The upper piston being of greater diameter than the lower, the tendency of the pressure is to raise the valve, unless it is held down by the pressure of a third piston of still greater diameter, working in a cylinder directly above the main valve.

The pressure on this third piston is regulated by the small slide-valve, working in the central chamber on the top head. This valve receives its motion from a rod extending into the hollow piston which, as shown in the drawing, has a knob at its lower end and a shoulder just below the top head. This valve chamber in the top head, by a suitable steam-port, is constantly in communication with the steam space between the two pistons of the main valve. The steam acting on the third piston and holding the main valve down, admits steam below the main piston; as the main piston approaches the upper head, the reversing-valve rod and its valve are raised until the slide-valve exhausts the steam from the space above the third, or reversing-piston, when the main valve is raised by the steam pressure on the greater area of its upper piston, which movement of the main valve admits steam to the upper end of the main cylinder.

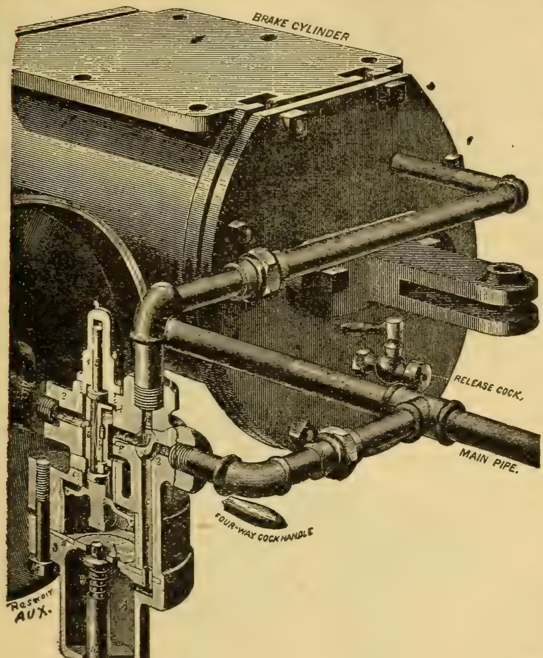
When the main valve is moved up to admit steam to the upper end of the cylinder, it opens an exhaust port at the lower end just below the lower steam-port, which latter is closed by the lower piston of the main valve; and when the main piston is on its upward stroke the upper exhaust-port is similarly opened.

The air valves of the pump are similar to those used in all pumps. The lift of a discharge valve should not exceed one-sixteenth of an inch, and the lift of receiving valves should not exceed one-eighth of an inch. Care should be taken to have the lift of the discharge valves exactly the same, otherwise the stroke of the pump will be quicker in one direction than in the other.


TO BOILER
EXHAUST
TO MAIN RESERVOIR
TO AIR STRAINER

TRIPLE VALVE.

The arrangement of the auxiliary reservoir, cylinder and triple-valve, with the latter in section, are shown in cut.



The triple valve has a piston 5, working in the chamber B, and carrying with it the slide-valve 6. Air entering from the main pipe passes through the four-way cock 13 by ports *a*, *c*, and the drain-cup A, and chamber B, forcing the piston 5 into its normal position as shown, thence through a small groove past the piston into the valve-chamber above, and into the auxiliary reservoir, while at the same time there is an op-

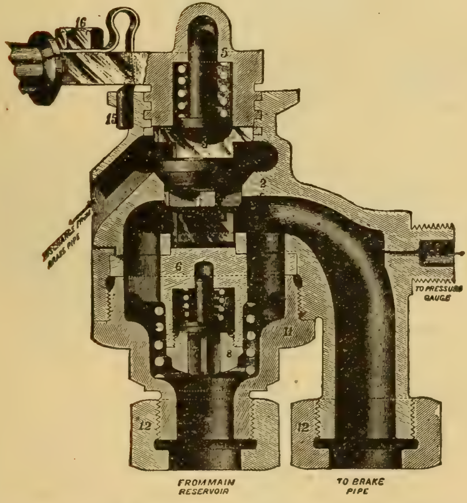
communication from the brake-cylinder to the atmosphere, through the passage *d*, *e*, *f* and *g*. Air will continue to flow into the auxiliary reservoir until it contains the same pressure as the main brake-pipe.

To apply the brakes with their full force, the pressure in the main brake-pipe is allowed to escape, whereupon the greater pressure in the auxiliary reservoir forces the piston down on the graduating-stem 8, and in so doing closes the feed opening past the piston. As the piston descends, it moves with it the slide-valve so as to permit the air to flow directly from the auxiliary revervoir into the brake-cylinder, which applies the brakes. The brakes are released by re-admitting pressure into the main brake-pipe from the main reservoir, which pressure, being greater than that in the auxiliary reservoir, forces the piston back to the position shown in the drawing, when the air in the brake-cylinder escapes. To apply the brakes gently, a slight reduction is made in the pressure in the main brake-pipe, which moves the piston down slowly until it is stopped by the graduating stem 8 and spring 9, at this point the opening *l*, in the slide-valve is opposite the port *f*, and allows air from the auxiliary reservoir to feed through a hole in the side of the slide-valve and through the opening *l*, into the brake-cylinder. When the pressure in the auxiliary reservoir has been reduced by expanding into the brake-cylinder, until it is the same as the pressure in the main brake-pipe, the graduating spring pushes the piston up far enough to close a small valve 7, which is placed in the feed opening *l*, of the slide-valve. This causes whatever pressure is in the brake-cylinder to be retained, thus applying the brake with a force proportionate to the reduction of pressure in the brake-pipe. To prevent the application of the brakes, from a slight reduction of pressure caused by leakage in the brake-pipe, a semi-circular groove is cut in the body of the car-cylinder, $\frac{9}{64}$ of an inch in width, $\frac{5}{64}$ of an inch in depth, and extending so that the piston must travel three inches before the groove is covered by the packing leather. A small quantity of air, such as results from a leak, passing from the triple-valve into the car cylinder, has the effect of moving the piston slightly forward, but not sufficiently to close the groove, which permits the air to flow out past the piston. If, however, the brakes are applied in the usual manner, the piston will be moved forward, notwithstanding the slight leak, and will cover the groove. It is very important that the groove shall be three inches long, and shall not exceed in area the dimensions given above.

When the handle of the four-way cock 13, is turned down there is a direct communication from the main brake-pipe to the brake-cylinder, the triple-valve and auxiliary reservoir being cut out, and the apparatus can be worked as a non-automatic brake by admitting air into the main brake-pipe and brake-cylinder, to apply the brakes. When from any cause it is desirable to have the brake inoperative on any particular car, the four-way cock is turned to an intermediate position, which shuts off the brake-cylinder and reservoir, leaving the main brake-pipe unobstructed to supply air to the remaining vehicles.

The drain cup A collects any moisture that may accumulate, and is drained by unscrewing the bottom nut.

ENGINEER'S BRAKE VALVE.



The handle 1 of the engineer's brake-valve terminates in a screw with a coarse thread, which compresses a spring 4 upon the top valve 3; this top valve fits into a slot in the handle

and into a slot in the main valve 6, so that the handle and the two valves must turn simultaneously. In the position shown in the drawing, which is for releasing the brakes, the top valve 3 leading to the atmosphere is kept closed by the compression of the spring 4, and the air passes freely from the main reservoir to the brake-pipe through the openings of the main valve and the body of the brake-valve. After the brakes are off, the handle is moved against the second stop, a short distance to the right, which turns the main valve so that the main passages to the break-pipe are closed. Air can, however, pass through the small valve 7, and thence to the brake-pipe through a small opening not shown in the drawing. This small valve 7 is held down by a spring whose resistance is equal to 20 lbs. per square inch, hence the pressure in the main reservoir will be 20 lbs. greater than that in the brake-pipe, which surplus pressure insures the certain release of the brakes when desired. To apply the brakes the handle is moved still further to the right, when the opening from the small valve 7 is also closed, cutting off all communication from the main reservoir to the brake-pipe, at the same time the action of the screw lifts the handle and relieves the spring 4 from pressure, when the air in the brake-pipe lifts the valve 3, and escapes, until an equilibrium is established between the air pressure and the pressure of the spring on the valve 3, thus reducing the pressure in the brake-pipe to an extent corresponding to the distance which this handle is moved.

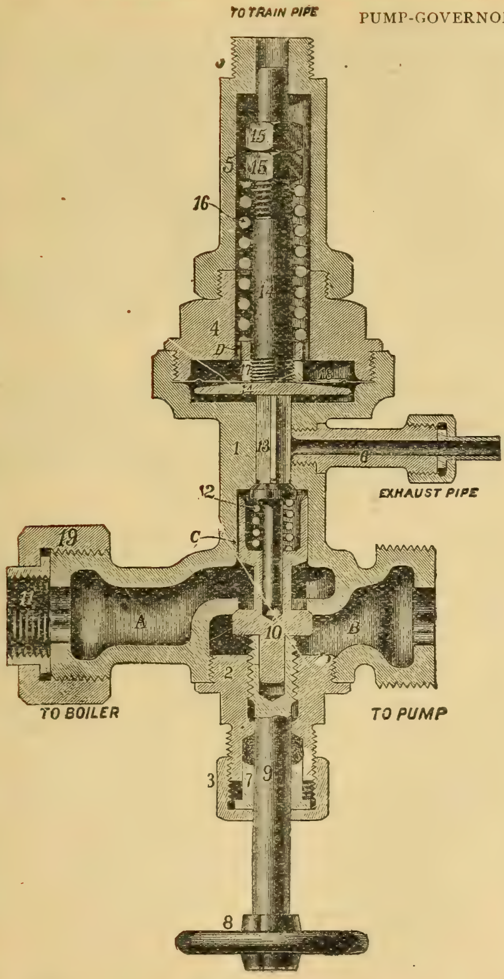
To apply the brakes suddenly the handle is turned the entire distance to the right, which relieves the spring of all compression, allowing the valve 3 to rise, and all of the air in the brake-pipe to escape.

After the train is stopped, the brakes are released by turning the handle to the position shown in the drawing.

The pump-governor is shown in the cut, the object of which is to automatically cut off the supply of steam to the pump when the air pressure in the train-pipe exceeds a certain limit, say 70 lbs.

The operation of this governor is as follows: The wheel 8 is screwed down so as to permit the valve 10 to be unseated by the excess of pressure on the upper side of the valve permitting steam to pass through the openings A and B to the pump. A connection is made from the train-pipe to the upper end of the governor, and the compressed air passes around the stem 14 to the upper side of the diaphragm plate 18, which is held to its position by the spring 16, which latter is of sufficient strength to resist a pressure of say, 70 lbs.

PUMP-GOVERNOR.



per square inch on diaphragm. As soon as the air pressure on the diaphragm 18 exceeds this amount, it forces the diaphragm down, unseating the valve 13, and allowing the steam on the upper side of the valve 10 to escape through the exhaust 6, which causes an excess of steam pressure on the lower side of the valve 10, forcing the valve against its seat, and cutting off the supply of steam to the pump.

When the pressure in the train-pipe is diminished by applying the brakes, the diaphragm is restored to the position shown by the action of the spring 16. The valve 13 is seated by the spring 12, and the steam pressure passing through the port C, accumulates on the upper side of the valve 10, forcing it down, and opening the passage for steam to the pump until the air pressure is again restored to the required limit of 70 lbs.

The use of the governor not only prevents the carrying of an excessive air pressure by the engineers, which may result in the sliding of the wheels, but it also causes the accumulation of a surplus of air pressure in the main reservoir while the brakes are applied, which insures the release of the brakes without delay. It also limits the speed of the pump and consequently the wear.

EQUALIZING VALVE.

The proper application of the brakes depends upon the amount of air discharged from the train pipe, and the manner in which it is discharged. The amount of air to be discharged also depends upon the length of train.

As stated in the general description of the brake apparatus, the brakes are applied by reducing the pressure in the train pipe, and are released by increasing the pressure. On long trains engineers have found it very difficult to discharge the air in such a way that they will not first cause a large reduction in the front portion of the pipe, and then an increase tending to release the brakes on the tender and two or three cars next; the increase of pressure being due to the expansion of the air in the pipes of the rear portion of the train. The equalizing valve which is shown in Plate 6 (which serves also as a large drain cup), is a device which automatically provides for the proper discharge of the air on all of the vehicles, back of the tender, the engineer having to discharge only the required amount from his brake-valve, and always a given amount for a certain degree of application, whether the train consists of one or fifty cars.

In the position shown, the air from the equalizing reservoir passes through the ports of the equalizing valve as shown by

the arrows and into the train pipe. When the pressure in the equalizing reservoir is reduced slightly to apply the brakes, the piston 15 moves down carrying the valve 11 from its seat and permitting the air in the train pipe to escape through the ports *d*, *e* and *g*, until the pressure in the train pipe equals that in the equalizing reservoir, when the piston and valve 11 return gradually to the position shown. When it is desired to apply the brakes quickly with full force a considerable reduction is made in the pressure in the equalizing reservoir and the piston moves down its entire distance carrying with it the slide valve 4 and uncovering the upper port *g*, while air is also allowed to escape through the port *f* and the lower port *g*, thus permitting a rapid escape of the pressure in the train pipe until it equals that in the reservoir, when the valve returns to the position shown.

INSTRUCTIONS.

General.—In making up trains all couplings must be united so that the brakes will apply throughout the entire train. The cocks in the brake-pipe must all be opened (handles pointing down), except that on the rear of the last car, which must be closed.

In detaching engines or cars the couplings must invariably be parted by hand; the cocks in the main brake-pipes must always be closed *before* separating the couplings, to prevent application of the brakes.

If the brakes are applied when the engine is not attached to the train or car, they can be released by opening the release cock usually put in the end of the brake-cylinder.

The adjustment of the break-gear should be such, that when the brakes are full on, the pistons in the brake-cylinders will not have traveled to exceed eight or nine inches. This will allow for wear of shoes, stretching of rods, springing of brake-beams, etc. In narrow gauge freight apparatus the adjustment must be such that the piston will not travel more than five or six inches.

Great care must be exercised when taking up the slack in the brake connections to have the levers and pistons pushed back to their proper places and the slack taken up by the under connection, or dead levers.

The brake-cylinders must always be kept clean so that they will readily release when the air has been discharged, and should be oiled once in three months. The last date of oiling should be marked on the cylinder with chalk.

For the automatic break the handle of the four-way cock must be turned horizontally. If turned down it will be

changed to the simple air-brake; if turned midway between these two positions, it will close communication with the brake-cylinder and reservoir, and should be so turned when desirable to have the brakes out of use on any particular car on account of the breaking of rods, etc. It is very important, in order to avoid detentions, to keep the handles of these four-way cocks in their proper positions.

In cold weather the triple valve should be drained frequently, to let out any water that may have collected. Slack the bottom nut of the triple valve about half a turn, let the water escape and screw it up again. The valve for the application of the brakes from the inside of the car should be kept tight, and must be examined by the inspectors.

Engineers must see that the steam-cylinder is kept well lubricated; that the air-cylinder is sparingly lubricated with a small quantity of 28° gravity West Virginia well oil; (tallow or lard oil must not be used in the air-cylinder); that the pump is constantly run, but never faster than is necessary to maintain the required air pressure; and that air from 50 to 60 pounds pressure for low speed or way trains, and from 70 to 80 pounds pressure for express trains is carried.

For ordinary stops the brakes should be applied lightly by opening the valve or cock and closing it gently when the pressure has been reduced from 4 to 8 pounds on the gauge.

The brakes are fully applied when the pressure shown on the gauge is reduced 20 pounds. Any further reduction is a waste of air.

In releasing the brakes, the handle of the brake-valve must be moved quite against the stop and be kept there for about ten seconds, and then moved back against the intermediate stop, which is the feed position, and where it must remain while the train is running.

Engineers, upon finding that the brakes have been applied by the train men or automatically, must at once aid in stopping the train by turning the handle of the brake-valve toward the right, thus preventing escape of air from the main reservoir.

The shoes of the driving-wheel brakes should be so adjusted by turning the screws that the piston moves up from 3 to 4 inches when the brakes are applied.

It is important to drain the water out of the main reservoir once a week, especially in winter time, and oftener if the pump-rod is not kept well packed.

If cars having different air pressures be coupled together, the brakes will apply themselves on those which have the

highest pressure. To insure the certain release of all the brakes in the train, and also that trains may be charged quickly, the engineer must carry the maximum pressure in the main reservoir before connecting to a train, and then put the handle of his brake-valve in the release position until the train is charged with air. If the brakes on the engine and tender thus apply themselves by being coupled to a train not charged, they should at once be taken off by opening the release cock from the brake-cylinders, which ought to be so arranged as to be worked from the foot-plate.

Train-Men.—After making up or adding to a train, or after a change of engines, the rear brakeman shall ascertain whether the brake is connected throughout the train.

When the hose couplings are not used for connecting the brakes between two vehicles, they must be attached to their dummy couplings.

When there is occasion to apply the brakes from the cars, the valve must be held open to allow the air to escape until the train is brought to a stand-still, but this method of application should only be used in cases of emergency.

Train-men must in all cases see that the hand-brakes are off before starting.

Before detaching the engine or any carriages, the brakes must be fully released on the whole train. Neglecting this precaution, or setting the brakes by opening a valve or cock when the engine is detached, may cause serious inconvenience in switching.

The pipes and joints must be kept tight, and when leaks are discovered they should be corrected, if serious, before the car is again used.

HOW TO APPLY AND RELEASE THE WESTINGHOUSE AUTOMATIC BRAKE.

The brakes, as has been explained, are applied when the pressure in the brake pipe is suddenly reduced, and released when the pressure is restored.

It is of very great importance that every engineer should bear in mind that the air pressure may sometimes reduce slowly, owing to the steam pressure getting low, or from the stopping of the pump, or from a leakage in some of the pipes when one or more cars are detached for switching purposes, and that in consequence it has been found absolutely necessary to provide each cylinder with what is called a leakage groove, which permits a slight pressure to escape without moving the piston, thus preventing the application of the

brakes when the pressure is slowly reduced, as would result from any of the above causes.

This provision against the accidental application of the brakes must be taken into consideration, or else it will sometimes happen that all of the brakes will not be applied when such is the intention, simply because the air has been discharged so slowly from the brake-pipe that it only represents a considerable leakage, and thus allows the air under some cars to be wasted.

It is thus very essential to discharge enough air in the first instance, and with sufficient rapidity, to cause all of the leakage grooves to be closed, which will remain closed until the brakes have been released. In no case should the reduction in the brake-pipe for closing the leakage grooves be less than four or five pounds, which will move all pistons out so that the brake-shoes will be only slightly bearing against the wheels. After this first reduction the pressure can be reduced to suit the circumstances.

On a long train, if the engineer's brake-valve be opened suddenly, and then quickly closed, the pressure in the brake-pipe, as indicated by the gauge, will be suddenly and considerably reduced on the engine, and will then be increased by the air pressure coming from the rear of the train; hence it is important to always close the engineer's brake-valve slowly, and in such a manner that the pressure as indicated by the gauge will not be increased, or else the brakes on the engine and tender, and sometimes on the first one or two cars will come off when they should remain on. It is likewise very important, while the brakes are on, to keep the engineer's brake-valve in such a position that the brake-pipe pressure cannot be increased by leakage from the main reservoir, for any increase of pressure in the brake.pipe causes the brakes to come off.

On long down grades it is important to be able to control the speed of the train, and at the same time to maintain a good working pressure. This is easily accomplished where the pressure-retaining valve is not in use, by running the pump at a good speed, so that the main reservoir will accumulate a high pressure while the brakes are on. When, after using the brakes some time, the pressure has been reduced to sixty pounds, the train pipes and reservoirs should be recharged as much as possible before the speed has increased to the maximum allowed. A greater time for recharging is obtained by considerably reducing the speed of the train just before recharging and by taking advantage of variation in the grades.

There should not be any safety-valves or leaks in the main reservoir, otherwise the necessary surplus pressure for quickly recharging cannot be obtained.

To release the brakes with certainty it is important to have a higher pressure in the main reservoir than in the main pipe. If an engineer feels that some of his brakes are not off, it is best to turn the handle of the engineer's brake-valve just far enough to shut off the main reservoir, and then pump up fifteen or twenty pounds extra, which will insure the release of all of the brakes; all of which can be done while the train is in motion.

For ordinary stops great economy in the use of air is effected by, in the first instance, letting out from eight to twelve pounds pressure, while the train is at speed, taking care to begin a sufficient distance from the station.

BRAKE POWER.

To obtain the best results, it is important to have the braking force proportioned to the weight of the car, or more particularly speaking, to the load carried by those wheels upon which brakes act. After long experience it has been decided to recommend such a proportion of brake levers that a pressure of fifty pounds per square inch on the brake piston will bring a force against the brake-blocks on each pair of wheels equal to the load carried by them; thus, owing to a great variation of cars, it is impossible to have uniform brake levers.

For convenience it has been found best to cut the brake connection which joins the brakes of both trucks and to interpose at this point the brake-cylinder, having with it two levers and a tie-rod. With this arrangement it is only necessary to get the proper portion of these cylinder levers.

The following rules will enable those whose duty it is to attach brakes to proportion the levers, so as to carry out the foregoing recommendation.

RULE FOR CALCULATING CAR LEVERS.

The air pressure is rated at fifty (50) pounds per square inch on piston, when the brakes are fully applied. (50 lbs. per square inch gives about 4,000 lbs. for 10-inch cylinder, and 2,500 lbs. for 8-inch cylinder.)

To find the leverage required.—Divide the weight of the car resting upon the brake-wheels by the *whole* pressure on piston.

To find proportion of brake beam levers.—Divide the *whole* length of lever by short end.

To find the total brake beam leverage.—Multiply proportion of lever by two (2) for the *Hodge* system, and by four (4) for the *Stevens'*.

To find proportion of cylinder lever.—Multiply the whole length of lever by either the required leverage, or the *total* brake beam leverage, and divide by the sum of both, the result will give the length of one end of the lever.

If the required leverage is greater than the *total* brake beam leverage, the long end of the lever must go next to the cylinder; if less, the short end must go next to the cylinder.

Dead levers must be made in the same proportion as the other truck levers.

Example—Hodge System.

Weight of car........................36,000 lbs.
Total pressure on 10-inch piston....... 4,000 "
Total length brake beam lever..........28 inches.
Length of short end of brake beam lever 7 "
Total length of cylinder lever..........24 "

$36{,}000 \div 4{,}000 = 9$, leverage required.
$28 \div 7 = 4 \times 2 = 8$, total brake beam leverage.
$24 \times 8 = 192 \div (8+9) = 11.3$, short end cylinder lever.
$24 - 11.3 = 12.7$, long end cylinder lever.

Example—Stevens' System.

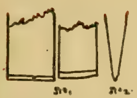
Total length of cylinder lever 36 inches.
$36{,}000 \div 4{,}000 = 9$, leverage required.
$28 \div 7 = 4 \times 4 = 16$, total brake beam leverage.
$36 \times 9 = 324 \div (9 + 16) = 12.96$, short end cylinder lever.
$36 - 12.96 = 23.04$, long end cylinder lever.

INFLUENCE OF ROADS AND WEATHER ON TRACTION.

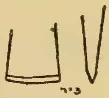
According to tests by E. Whyte-Smith, and communicated to the Institute of Electrical Engineers, the pull required per ton of vehicle for various roads and for three different conditions of weather is given in the following table:

Asphalt,	22	23	22	Pull in lbs. per ton.
Wood,	22	31	36	
Macadam (good),	52	50	49	
Macadam,	60	51	50	
Macadam (soft),	97	51	52	

COLD CHISELS.

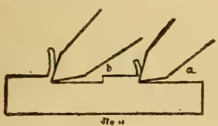


Figures 1 and 2 are drawings of flat chisels. The difference between the two is that, as the *cutting edge* should be parallel with the flats on the chisel, and as Fig. 1 has the widest flat, it is easier to tell with it when the cutting edge and the flats are parallel; therefore the broad flat is the best guide in holding the chisel level to the surface to be chipped. Either of these chisels is of a proper width for wrought iron or steel, because chisels used on these metals take all the power to drive that can be given with a hammer of the usual proportions for heavy clipping, which is: Weight of hammer, 1¾ lbs.; length of hammer-handle, 13 in.; the handle to be held at its end, and swinging back about vertically over the shoulder.

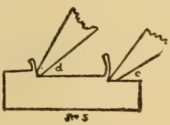


If so narrow a chisel be used on cast iron or brass with full force hammer blows, it will break out the metal instead of cutting it, and the break may come below the depth wanted to chip, and leave ugly cavities.

So for these metals the chisel must be broader, as in Fig. 3, so that the force of the blow will be spread over a greater length of chisel edge, and the edge will not move forward so much at each blow, therefore it will not break the metal out.



Another advantage is that the broader the chisel the easier it is to hold its edge fair with the work surface, and make smooth chipping. The chisel-point must be made as thin as possible, the thickness shown in sketches being suitable for new chisels. In grinding the two faces to form the chisel, *be careful to avoid grinding them round*, as shown in *a* in the magnified chisel ends in Fig. 4; the proper way is to grind them flat, as in *b* in the same sketch. Make the angle or edge of these two faces as sharp or acute as you can because the chisel will then cut easier.



For cutting brass, hold the chisel about the angle shown in *c*, Fig. 5; for steel, that at *d* same figure. The difference is, that with hard metal the more acute angle dulls too quickly.

For heavy chipping, the point may be made flat as in Fig. 1., or curved as in

Fig. 3., which is the best, because the corners are relieved from duty, and are therefore less liable to break. The advantage of the curve is greatest in fine chipping, because, as seen in Fig. 6, a finer chip can be taken without cutting with the corner, and these corners are exposed to the eye in keeping the chisel edge level with the work surface.

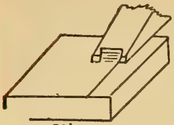


Fig. 6

In any case do not grind the chisel hollow in its length, as in Fig. 7, or as shown exaggerated in Fig. 9, because, in that case, the corners will dig in and cause the chisel to be beyond control; besides that; there will be a force, that, acting on the wedge principle, will operate to spread the corners and break them off.

Fig. 7

Fig. 8

Do not grind the faces wider on one side than on the other of the chisel, as in Fig. 8, because, in that case, the flat of the chisel will form no guide to let you know when the cutting edge is level with the work surface. Nor must you grind it out of square with the chisel body, as in Fig. 10, because, in that case, the chisel will be apt to jump sideways at each hammer-blow.

Fig. 9

A quantity of metal can be removed quicker by using the cape chisel in Fig. 11, to first cut out grooves, spacing these grooves a little narrower apart than the width of the flat chisel, and thus relieving its corners. The chisel end must be shaped as at *a* and *b*, and not as at *c* in Fig. 11, so as to be able to move it sideways, to guide it in a straight line, and the parallel part at *c* will interfere with this, so that if the chisel is started a very little out of line, it will go still further out of line, and cannot be moved sideways to correct the fault.

Fig. 10

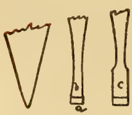


Fig. 11

The round-nosed chisel, Fig. 12, must not be made straight on its convex edge; it may be straight from *h* to *g* but from *g* to the point, it must be beveled, so that by altering the height of the chisel head it is possible to alter the depth of the cut.

Fig. 12

The diamond point chisel in Fig. 14 and 15, must be shaped to suit the work, because if it is not to be used to cut out the corners of very deep holes, you can bevel

it at *m*, and these bring its point *x*, central to the body of the steel, as shown by the dotted line *q*, rendering the corner *x* less liable to break, which is the great trouble with

Fig. 14

Fig. 15

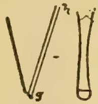


Fig. 13

this chisel; but in cutting deep holes the bevel at *m* must be omitted, and you must make the edge straight, as at *r* in Fig. 15.

The side chisel obeys the same rule, so you may make it bevel at *w*, as in Fig. 16, for shallow holes, and lean it well over in using, and make the side *v w* straight along its whole length for deep holes; but in all chisels for slots or mortises it is desirable to have if circumstances will permit, some bevel on the side that meets the work, so that the depth of the cut can be regulated by moving the chisel head.

Fig. 16

In all these chisels, the chip on the work steadies the cutting end, and it is clear, that the nearer you hold the chisel at its head the steadier you can hold it, and the less the liability to hit your fingers, while the chipped surface will be smoother.

To take a chip off wrought iron, if it is a heavy chip, stand well away from the vice, as an old hand would do, instead of close to it; if, instead, you wish to take a light chip, you must stand nearer to the work, so that you can watch the chisel's action and keep its depth of cut level. In both cases you must push the chisel forward to its cut, and hold it as steadily as possible.

It is a mistake to move it at each blow, as many do, because it cannot be so accurately maintained at the proper height. Light and quick blows are always necessary for the finishing cuts, whatever the kind of metal may be.

TURNING OR LATHE TOOLS FOR METALS.

Few lathe tools, except scrapers, can be used indiscriminately for cast iron, wrought iron or brass; each metal needs its particular set of tools, differing not so much in the shape of their cutting edges, as in the angles which they make with the surface of the work to be turned. Thus, Figs. 17, 18,

19 are each intended to represent in profile the ordinary roughing-down tool, but their angles are very different, the one from the other. Fig. 17 being only suitable for wrought iron, Fig. 18 for cast iron and Fig. 19 for brass. In all

Fig. 17

Fig. 18

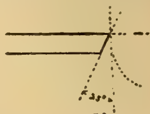


Fig. 19

these, everything (temper of course excepted) depend upon the angle at which the tools are ground. The brass tool with the flat face would not cut the iron, but would simply scratch it; while the iron tools would hitch in the brass and tend to "chatter," or "draw-in." Neither would the tool ground at an acute angle for wrought iron, cut cast metal, but would itself become broken off at the tip, while the thicker cast iron tool would not take clean shavings off wrought iron. Fig. 20 is a common roughing tool for cast iron. The side view gives a proper angle to insure a clean cut without breaking the top across in the direction of the dotted line. The angle is drawn on the supposition

Fig. 20

that the tool is held horizontally, as indeed it should be, but a tool that will not cut nicely in a horizontal direction will often work by inclining it at a slight angle. Neither is the angle at which a tool should be ground, in order to cut well horizontally, necessarily the same. It should be about 65° with the verical for cast iron, but may vary slightly either way.

In fact, not one workman in ten could say what angle he grinds his tools to; he simply judges the proper angle by his eye. The angle which the front of the tool makes with the work may vary somewhat more than the upper face, depending upon the diameter of the work to be turned, but should not slope more than 4° or 5° from the vertical for cast iron (Fig. 18). If it becomes excessive the tool is weak and soon breaks off.

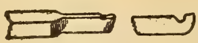


Fig. 21

Fig. 22

These details may seem trivial, but they are really of the utmost importance. These sketches are taken from tools in

actual use and doing their work well. Fig 21 shows a round nose, Fig. 22 a parting tool, Fig. 23 a knife-tool for finishing edges and faces of flanges, and ends and sides of work, either right or left-handed (Fig. 24). The end views of these tools show the upper and clearance angles, which are about the same as in Fig. 18, but may vary somewhat according to the work required.

Figs. 25 are boring-tools for hollow cylinders, tools capa-

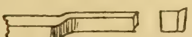


Fig 23 End view of Tool

Fig 24 End View

ble of much modification, their cutting edges not only taking the forms of all other tools, but each form also being often right and left-handed. In reference to the more usual shape, that of the round nose for boring, when used simply as a roughing tool, the shape *b* showing it in place, with the axis of the cutting angle in the direction of the dotted line, is better than that of *a*, because in *b* the true cutting edge is carried forward. Hence, in work-shops the cutting tools generally take the form *b*, and the scrapers form *a*.

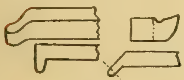


Fig 25

Fig. 26 is a square nose for taking finishing cuts, and Fig.

Fig 26

Fig 27

Fig 28

27 is a tool for scraping; Fig. 28 is a spring tool, also used for finishing a turned surface; Figs. 29 and 30 are for finishing hollows and rounded parts of work, and are either kept in different sweeps or ground to circles as wanted. These

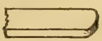


Fig 29

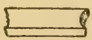


Fig 30

latter forms are only used for smoothing and polishing, and, as they act simply as scrapers, are flat on their upper surfaces.

For grinding tools, a very handy little grindstone may be made in this fashion (Fig. 31). A piece of broken grindstone, 2 inches thick, is rudely clipped round to 7 inches in diameter, and a ½ inch hole bored through the center with a common stone-bit; two wooden washers, *a'*, ½ inch thick by 4 inches in diameter, also have ½

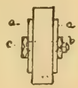


Fig 31

inch holes bored in their centers. A ½ inch bolt, *b*, thrust through the whole keeps them firmly together with the stone in the center.

As the stone is intended to work chucked between centers, a small drilled hole is run both into the bolt head and into the screwed end, and a V shaped slit, *c*, is filed in the head to hold the fork.

Turned up in place, it makes an efficient little grindstone, in readiness for use the moment it is slipped into the lathe. A shallow tin pan slipped between the stone and bed will catch any mess that may be made.

The grindstone or emery wheel alone is used to sharpen roughing-down tools; but those used for smoothing and polishing should have the edge finished with an oil-stone.

NOTES ON BELTING.

Having your machinery, shafting and pulleys properly arranged, preparatory to belting, the next thing to be determined is the length and width of the belts. When it is not convenient to measure with the tape-line the length required, the following rule will be found of service:

Add the diameter of the two pulleys together; divide the result by 2, and multiply the quotient by 3¼; then add this product to twice the distance between the centers of the shafts, and you have the length required. The width of the belt depends on three conditions:—1, The tension of the belt; 2, the size of the smaller pulley and the proportion of the surface touched by the belt; 3, the speed of the belt.

The working adhesion of a belt to the pulley will be in proportion both to the number of square inches of belt contact with the surface of the pulley, and also to the arc of the circumference of the pulley touched by the belt. This adhesion forms the basis of all right calculations in ascertaining the width of belt necessary to transmit a given horse-power.

In locating shafts to be connected by belts, care should be taken to secure a proper distance one from the other. This distance should be such as to allow a gentle sag to the belt when in motion. A general rule may be stated as thus: When narrow belts are to be run over small pulleys, 15 feet is a good average, the belt showing a sag of 1½ to 2 inches.

For larger belts, working on larger pulleys, a distance of 20 to 25 feet does well, with a sag of 2½ to 4 inches.

For main belts, working on very large pulleys, the distances should be from 25 to 30 feet, the belts working well, with a sag of 4 to 5 inches.

If the distance be too great the weight of the belt will produce a very heavy sag, which is a decided objection, producing great friction on the bearings, while at the same time the belt will have an unsteady flopping motion which will destroy both the belt and machinery. Connected shafts should never be placed one directly over the other, as in that case the belt must be kept very tight to do the work.

It is best that the angle of the belt with the floor should not exceed 45 degrees. It is also best in locating the machinery and shafting so that the belts will run off on opposite sides, thus relieving the bearings from the friction incident to having the tension all on one side.

The pulleys should be of as large a diameter as can be admitted, provided they will not produce a speed of more than 3,750 feet a minute.

Pulleys should be a little wider than the belts required for the work.

The motion of driving should run *with*, and not *against*, the laps of the belts.

In using tightening or guide pulleys, apply them to the slack side of the belt and near the smallest pulley. Belts to run at high speed should be made as straight and uniform in section and density as possible; if practicable, make them endless; that is, with permanent joints, A loose running belt will last and wear longer than a tightly-drawn belt. Tightness is evidence of overwork and disproportion. *Never add to the work of a belt so much as to overload it.*

The strongest part of a belt leather is near the flesh side, about one-eighth of the way through from that side.

It is best to run the grain (or hair) side of the belt next to the pulley.

The flesh side is not liable to crack, as the grain side will do when the belt is old; hence, it is better to *crimp* the grain instead of *stretching* it.

The grain side next to the pulley will give the belt thirty per cent. more power than if the flesh side was on the pulley.

The belt, as well as the pulley adheres best when smooth, and the grain side is the smoother.

A belt adheres much better and is less liable to slip when at a high speed than at a low speed. Therefore it is best to gear a mill with small pulleys and run them at high velocity, than with large pulleys and to run them slower. Besides, the cost is less, and appearance much neater.

Keep belts clear of grease and accumulation of dust especially from contact with lubricating oils.

Protect leather belts from water and moisture.
Belts should be kept soft and pliable.

RULES FOR CALCULATING THE HORSE-POWER WHICH CAN BE TRANSMITTED BY BELTING.

To find the horse-power a single belt can transmit, the size of the pulley and the width of the belt being given.—Multiply the diameter of the pulley in inches by the number of revolutions per minute; multiply this product by the width of the belt in inches, and divide by 2,750; the quotient will be the horse-power.

For a double belt divide the last product by 1,925 instead of 2,750.

The horse-power to be transmitted, and the size of the pulley being known, to find the width of the belt required.—Multiply the horse-power by 2.750 if the belt is single (by 1,925 if the belt is double); also multiply the diameter of the pulley in inches by the revolutions per minute. Divide the first product by the last, and the quotient will be the width of belt required.

The horse-power and width of belt being known, to find the diameter of the pulley.—Multiply the horse-power by 2,750 for a single belt (or 1,925 if double); also multiply the revolutions per minute by the width in inches; divide the first product by the last, and the quotient will be the diameter of the pulley in inches.

The horse-power, diameter of pulley and width of belt being known, to find the number of revolutions necessary.—Multiply the horse-power by the 2,750 if a single belt (1,925 if double); also multiply the diameter of the pulley in inches by the width of the belt in inches; divide the first product by the last, and the quotient will be the number of revolutions per minute required.

It is assumed in these rules that the belts are open, and that the pulleys—both driver and driven—are of same diameter. If, however, the pulleys are of different diameters the smaller pulley will have less surface in contact with the belt than on the larger pulley. If this surface—called the *arc of* contact, is less than one-half the circumference, the above rules must be modified. In that case, instead of using the numbers 2,750 for single belts, and 1,925 for double belts, use the following: When the arc of contact of the smaller pulley is

		Single Belt.	Double Belt.
[illegible]	the circumference	6,080	4,25[illegible]
[illegible]	" "	4,730	3,31[illegible]
[illegible]	" "	4,400	3,080
[illegible]	" "	3,850	2,700
[illegible]	" "	3,410	2,390
[illegible]	" "	3,220	2,250
[illegible]	" "	2,750	1,925

TABLE SHOWING STRENGTH OF BELTING MATERIALS.

MATERIALS.	Breaking Strain for 1 in. Wide.	Thickness.
Oak-tanned leather	1,250	1–4 in.
Oak-tanned leather	1,166	1–4 in.
Oak-tanned leather	750	1–4 in.
Sugar-tanned leather	725	1–4 in.
Ordinary tanned leather	550	3–16 in.
3-ply rubber	1,000	7–32 in.
Cotton-duck	200	
Raw-hide	958	5–32 in.
Flax	1,489	

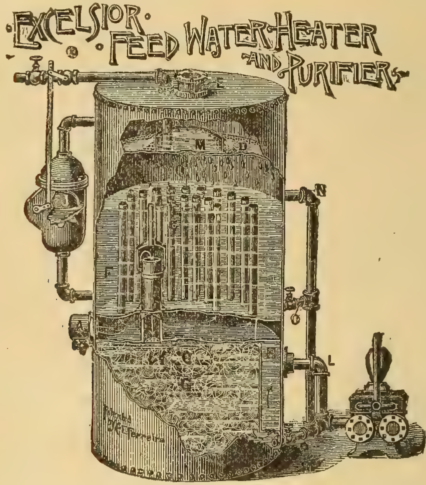
An examination of this table will show that it will be safe to estimate the breaking strain of leather and rubber belting at 4,000 pounds to the square inch of section, or 1,000 pounds to each inch of width. Cotton belting is usually laid 4-ply for the narrower widths, making, according to tables, a breaking strain of 800 pounds to the inch of width. This brings the three principal materials very near together.

It is usual in allowing for the working strength of belts, to make the safe working strain 1 to 16 of the actual breaking strain, so that we have in this practice, 166 pounds as the working strain for leather and rubber to each one inch of width, and 133 pounds for that of 4-ply cotton belting.

FEED-WATER HEATERS.

All water used in the generation of steam for mechanical purposes is more or less heavily impregnated with foreign matter held in solution; lime, magnesia, sulphur, iron, silica, etc., or mud, sand and vegetable impurities held in suspension.

Where feed-water is pumped directly into boilers without first being purified, the heat used for generating steam sets free all impurities, and they are precipitated upon the inner surfaces of the boiler in the form of scales or incrustation.



This scale is a non-conductor of heat, and as it is interposed between the water and iron of the boiler, causes a great deterioration of the boiler and corroding the iron. Besides, the impurities in the water will cause priming and foaming, which injures the engine by allowing grit to work into the cylinder, causing explosions, stoppages, delays and expensive repairs.

To eradicate these evils various solutions and patented nostrums are introduced into the boiler; but this is a danger-

ous and bad practice, as the majority of them are not only valueless, but injurious. Sal-soda, however, makes a good *purge*, as it is called, and may be used with good effect where the water causes the boiler to prime or foam.

It is more economical, however, to purify the water before it is fed into the boiler, and to this end, a good feed-water heater and filterer is necessary.

The subject of feed-water heaters has not received much attention until within the last few years, but no plant is now considered complete without one. Besides purifying the water, the heater will increase the temperature of the water from its initial temperature to 200° (in some heaters). This it does by means of the exhaust steam from the engine passing through it, and every degree of temperature raised in the feed-water, is so much clear gain in economy of fuel, as the table on page 86 will show.

For instance, if the feed-water enters the heater at 60° and is delivered to the boiler at 180°, there is a saving in fuel of 10.46 per cent. If the feed-water enters the heater at 40° and is delivered to the boiler at 200°, the saving in fuel would be 13.71 per cent.

The cut of the feed-water heater and purifier represents a standard heater called the Excelsior, made in Chicago, and heats the water up to 212°, or boiling point.

It is thus readily seen that a saving of 13 per cent. in fuel by the use of a good feed-water heater is a matter of some considerable importance. A further saving, which cannot be so accurately calculated, is the save in the wear and tear of the boiler. The forcible injection of a stream of cold water into a highly heated vessel is bound to make a sudden variation in the degree of temperature, and any such variation is bound to affect the boiler to a greater or less extent. Where the water for steam purposes is drawn from the city pipes, the consumer is charged for the amount of water he uses, as measured by the water meter. This expense can be lowered fully 30 per cent. by using a feed-water heater, into which the exhaust of the engine passes. The steam is condensed and is fed back into the boiler again, so that the water, instead of passing into the open air from the exhaust pipe, is collected and again made to do duty as steam.

The feed-water heater should be placed in such a position as to be easily accessible on all sides, so that it can be readily and easily cleansed, and the sediment removed without dirtying up the engine or boiler room.

Table Showing the Percentage of Saving of Fuel Effected by Heating Feed-Water,

Steam Pressure 60 Pounds.

Terminal Temperature of Feed-Water.	Initial Temperature of Feed-Water.												
	32°	40°	50°	60°	70°	80°	90°	100°	120°	140°	160°	180°	200°
60°	2.39	1.71	3.86	0									
80°	4.09	3.43	2.59	1.74	0.88	0							
100°	5.79	5.14	4.32	3.49	2.64	1.77	0.90	0					
120°	7.50	6.85	6.05	5.23	4.40	3.55	2.68	1.80	0				
140°	9.20	8.57	7.77	6.97	6.15	5.32	4.47	3.61	1.84	0			
160°	10.90	10.28	9.50	8.72	7.91	7.09	6.26	5.42	3.67	1.87	0		
180°	12.60	12.00	11.23	10.46	9.68	8.87	8.06	7.23	5.52	3.75	1.91	0	
200°	14.30	13.71	13.00	12.20	11.43	10.65	9.85	9.03	7.36	5.62	3.82	1.96	0
220°	16.00	15.42	14.70	14.00	13.19	12.33	11.64	10.84	9.20	7.50	5.73	3.93	1.98
240°	17.79	17.13	16.42	15.69	14.96	14.20	13.43	12.65	11.05	9.37	7.64	5.90	3.97
260°	19.40	18.85	18.15	17.44	16.71	15.97	15.22	14.45	11.88	11.24	9.56	7.86	5.96
280°	21.10	20.56	19.87	19.18	18.47	17.75	17.01	16.26	14.72	13.02	11.46	9.73	7.94
300°	22.88	22.27	21.61	20.92	20.23	19.52	18.81	18.07	16.49	14.99	13.37	11.70	9.93

SETTING SLIDE-VALVES.

We will suppose the engine to be new, and of the rocker type, and horizontal.

First find in which direction the engine is to run. Set the crank on the forward dead-center by means of a square, or by a line. *Be sure that it is on the center.* Set the eccentric at right angles to the crank, high side turned up. If the engine was to run the other way the eccentric would have to be turned down, or the engine turned on the other center.

To get the eccentric accurately at right angles I use the following method: I get a planed board and fasten it wherever I can, at the eccentric side of the engine, in such a position that it will come under the eccentric rod. I put on the straps and rods loosely. I then hold, or fasten a pencil to the rod, and have an assistant turn the eccentric once around, holding the pencil so it will mark the exact travel of the rod on the board. I find the center of this line with a pair of dividers or a rule. I turn the eccentric up until the pencil comes to the center of line. Fasten the eccentric loosely so it won't slip. It is now at right angles to the crank, and in the neutral position. If the valve had no lap nor lead the eccentric would now be properly set. Next I find the exact center of the valve and mark it with a fine line in such a manner that the line will show on top of the valve. I also find the center of all the parts. I mark a fine line running up the side of steam-chest so it can be seen above the valve. I then place the valve over the parts, and bring line on valve and line on steam-chest, so they are together This puts the valve in its central or neutral position. I put in the rod and connect it to rocker-arm. I plumb the rocker with a plumb-line and bob so that the center of eccentric rod-pin will be cut by the line, and screw jamb-nuts up to the valve with my fingers. I now fasten the valve so it can't move. That is, if I can, without too much trouble. Valve, rocker and eccentric are now in the neutral position, and temporarily fastened. The eccentric-rod must now be brought into such a position that it will hook onto the rocker-arm without moving it a hair's breadth. I now turn the eccentric the way the engine is to run until I have the proper lead or opening. If I have been accurate in my work the valve is properly set. To prove it I put the engine on the other center, and if the lead is the same I fasten everything. The valve is set. The distance I turned the eccentric

from a right angle with the crank is known as the angle of advance.

POINTS ON BOILER'S CIRCUMFERENCE.

In text-books we have the areas and circumferences of circles, but if we don't know how to use them, they are of no use to us. They are all right for tin or any thin stuff, but not for boiler-makers. As an instance, supposing we have a boiler to make 36″ diameter. If we look at the table of circumference we will find that it takes 113.098″—one hundred and thirteen inches and about one-sixteenth. This would not give either side or outside diameter, but would be the thickness of iron, less, if we were wanting inside measurement, or more, if for outside diameter. If the shell is of ¼″ material we must add the ¼″ to the diameter for inside diameter, making it 36¼″. For this we will find that it takes 113.883″ or a little over $\frac{7}{8}$ of an inch more, and for outside diameter we must take off the thickness of material, making the diameter 35¾″. For this it would take 112.312″, or about 113¼, as near as can be got by the common rule. There are several ways for figuring this. My plan is to multiply the diameter by three, and divide the same by seven, and add the product together. But it must be understood that neither this or the taking from tables in text-books gives laps. In working this rule, three times 36¼ is 108¾, and 7 into 36 will go 5 times and $\frac{1}{7}$ over, but instead of calling it $\frac{1}{7}$ call it $\frac{1}{8}$, and we have it on the rule. For the small course there is a difference of six and one-half times the thickness of material. This will hold good in all cases, so that if we get one course out by figuring, the other may be got by adding or subtracting this difference. As in the majority of men, they have a holy horror of figures, especially boiler-makers, in "manufactories." Another thing that is not generally understood among them is the properties of a circle. A circular vessel will contain a greater quantity than a vessel of any other shape, made of the same amount of material. That is to say, if an iron plate, six feet long, was rolled to a circle and a bottom put in it, it would hold more water than if it was bent square or any other shape. The areas of circles are to each other as the squares of their diameters. Any circle twice the diameter of another, is also four times its area and twice its circumference. The diameter of a circle is a straight line drawn through its center, touching both sides. The radius of a circle is half the diameter, or the distance from the center to the circumference.

HOW TO SET A LOCOMOTIVE ECCENTRIC.

I am familiar with the rule for setting a slipped eccentric by placing engine on center and marking the stem by using the eccentric that is not slipped, for a guide, but what I want is a rule to set a slipped eccentric without another to go by; suppose I slip both eccentrics on the right side, what am I to do, and why should I do it? *A.*—If both eccentrics on a side slip stop at once, protect your train, and be sure the eccentrics are slipped, before you go to work on them; if they are "off" beyond a doubt, take off the chest cover and pinch the engine onto the center (no matter which center), take the eccentric next the box first, as you can get the other out of the way to work at it; if this is the go-ahead eccentric, place the reverse lever in forward notch and turn the eccentric around on the shaft *ahead* until the port opens $\frac{1}{10}''$ or $\frac{1}{8}''$, the amount of lead you want, and fasten it there; put the reverse lever in the back notch and turn the back-up eccentric *back* until the port is open, the same as it was with the go-ahead, and fasten eccentric Where only one eccentric it slipped, it is best to set it by marking the stem; that plan is the quickest, as you do not have to take off the cover. You will readily see that when one side is on the center, the engine will go either way, as steam is admitted to one side or the other of the piston on the other side of locomotive, as it is in the center of cylinder, and by setting the eccentrics to give lead on the center, and by turning them the right way, you can't get them wrong. A good engineer will always save himself all this trouble and delay on the road by marking the eccentrics in their proper position, if he is running a locomotive without eccentric keys.

CHIMNEYS.

The following table shows the proportion of sizes of chimneys to the horse-power of the boiler using the chimney. The measurements given for the diameter is for *internal* diameter. By referring back to the article on "Steam Boilers" commencing at page 45, the rules given for fire grate surface can be utilized in connection with this table in planning for the steam power of a plant. This table has been carefully compiled and arranged, and the proportions given may be accepted as correct. Too little attention is paid to chimneys, and the furnace is often blamed for poor results when the ckimney is the part in wrong. Proper draught is all-important, and one chimney should never be made to do the work of two.

SIZES OF CHIMNEYS WITH APPROPRIATE HORSE-POWER OF BOILERS.

Diameter in inches.	HEIGHT OF CHIMNEYS AND COMMERCIAL HORSE-POWER.											Side of Square inches.	Effective Area Square ft.	Actual Area Square ft.
	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.			
18	23	25	27									16	0.97	1.77
21	35	38	41									19	1.47	2.41
24	49	54	58	62								22	2.08	3.14
27	65	72	78	83								24	2.78	3.98
30	84	92	100	107	113							27	3.58	4.91
33		115	125	133	141							30	4.48	5.94
36		141	152	163	173	182						32	5.47	7.07
39			183	196	208	219						35	6.57	8.30
42			216	231	245	258	271					38	7.76	9.62
48				311	330	348	365	389				43	10.44	12.57
54					427	449	472	503	551			48	13.51	15.90
60					536	565	593	632	692	748		54	16.98	19.64
66						694	728	776	849	918	981	59	20.83	23.76
72						835	876	934	1023	1105	1181	64	25.08	28 27
78							1038	1107	1212	1310	1400	70	29.73	33.18
84							1214	1294	1418	1531	1637	75	34.76	38.48
90								1496	1639	1770	1893	80	40.19	44.18
96									1876	2027	2167	86	46.01	50.27

External diameter at the base should be one-tenth of the height, unless supported by some other structure. The "batter" or taper should be from 3-16 to ¼ inch to the foot of each side.

Thickness of brick work, one brick (8 or 9 inches) for 25 feet, from top downward.

If the inside diameter exceed 5 feet, the top length should be 1½ brick, and if under 3 feet it may be ½ brick for ten feet.

DEFINITIONS AND USEFUL NUMBERS.

ARITHMETICAL SIGNS USED IN THIS BOOK.

$+$ Plus, or more, the sign of addition, as $2 + 2 = 4$.

$-$ Minus, or less, the sign of subtraction, as $4 - 2 = 2$.

$\times$ signifies multiplied into or by, as $3 \times 3 = 9$.

$\div$ signifies divided by, as $10 \div 5 = 2$.

$=$ signifies equality, or equal to, as $4 + 4 = 8$.

: :: :, the sign of proportion, as $2 : 4 :: 3 : 6$; which reads thus: as 2 is to 4 so is 3 to 6.

$\sqrt{\ }$, the sign of the square root, as $\sqrt{49} = 7$; that is, 7 is the square root of 49, or 7 is the number which, if multiplied by itself, produces 49.

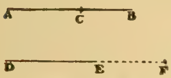
7^2 means the square of 7, or that 7 is to be squared or multiplied by itself. The square of any number is the product of the number multiplied by itself.

7^3 means the cube of 7, or that 7 is to be multiplied by 7, and again by 7. The cube of any number is the product of that number multiplied by itself, and again by itself.

SQUARE MEASURE AND CUBIC MEASURE.

144 square inches	=	1 square foot.
9 square feet	=	1 square yard.
1 728 cubic inches	=	1 cubic foot.
27 cubic feet	=	1 cubic yard.

DEFINITIONS OF TERMS WHICH ARE EMPLOYED IN THE FOLLOWING RULES.



Figs. 1 and 2.

A Point has a position without magnitude, as at C, Fig. 1.

A Line has length without breadth, as D E, Fig. 2.

A Right Line is the shortest distance between any two points, P P, Fig. 3.

Fig. 3.

A Superficies has length and breadth only. Fig. 4.

Fig. 4.

Fig. 5.

A Solid has length, breadth and thickness. Fig. 5.

An Angle is the opening of two lines having different directions, and is either Right, Acute, or Obtuse.

A Right Angle is made by a line being drawn perpendicular to another, as in Fig. 6.

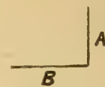


Fig. 6.

7.

An Acute Angle is less than a Right Angle. Fig. 7.

An Obtuse Angle is greater than a Right Angle. Fig. 8.

Fig. 8

A Triangle is a figure bounded by three straight lines. Figs. 9, 10, 11.

Fig. 9.

An Equilateral Triangle is a Triangle of which the three sides are equal to each other. Fig. 9.

An Isosceles Triangle has two of its sides equal. Fig. 10.

Fig. 10.

Fig. 11.

A Scalene Triangle has all its sides unequal. Fig. 11.

A Right-angled Triangle has one Right Angle. Fig. 12.

Fig. 12.

A Square is a 4-sided figure having all its sides equal, and all its angles Right Angles. Fig. 13.

Fig. 13.

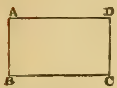


Fig. 14.

A Rectangle is a 4-sided figure, having its angles Right Angles, and of which the length exceeds its breadth. Fig. 14.

An Arc is any part of the circumference of a circle, as A C B, Fig. 15.

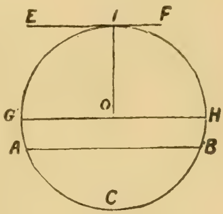


Fig. 15.

A Chord is a right line joining the extremities of an Arc, as A B, Fig. 15.

A Segment of a Circle is any part bounded by an Arc and its Chord, as the Segment A C B, Fig. 15.

A Diameter is a straight line passing through the center of a Circle, and bounded by the circumference at both ends; as G H, Fig. 15.

A Semicircle is half a Circle, as G C H, Fig. 15.

The Circumference of a Circle is the outside boundary line described on the center with a length equal to the radius.

A Quadrant is a Quarter Circle, as G O I, Fig. 15.

A Tangent is a Right Line that touches a Circle without cutting it, as E F, Fig. 15.

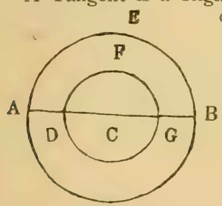


Fig. 16.

Concentric Circles are Circles having the same center, and the space included between their circumferences is called a Ring. Fig. 16.

Lbs. Pounds	×	.009	=	Hundredweights.
"	×	.00045	=	Tons.
Diameter of Circle	×	3.1416	=	Circumference.
Circumference	×	.3183	=	Diameter.
Cubic inches	×	.003607	=	Gallons.
Cubic feet	×	6.232	=	Gallons.
Cylindrical in.	×	.002832	=	Gallons.
Cylindrical feet	×	4.895	=	Gallons.
Diameter of circle	×	.88622	=	Side of equal sq.
Side of a square	×	1.128	=	Diam. of circle of equal area.
Square of the diameter	×	.7854	=	Area of circle.
Radius of circle	×	6.2831	=	Circumference.
Cubic inches	÷	277.274	=	Gallons.
Cylindrical inches	÷	353.03	=	Gallons.
Cubic ft. of water	×	35.9	=	Tons.
Gallons of water	×	10	=	Pounds weight.

MENSURATION.

To find the circumference of a circle when the diameter is given.—Multiply the diameter by 3.1416; the product is the circumference.

A common method of calculating the circumference is to multiply the diameter by 3, and add $\frac{1}{7}$ of the diameter to the product. The sum is the circumference, very nearly. Or, what amounts to the same thing, multiply the diameter by 22, and divide the product by 7.

Another method of finding the circumference is to multiply the diameter by 3, and add $\frac{9}{16}$ inch to the product for every foot-length in the product. The reason for adding $\frac{9}{16}$ inch for each foot of the product, is, that it is the same in effect as the addition of $\frac{1}{7}$ of the diameter. As the product is equal to three times the diameter, the addition to be made per foot of product should be only a third of the addition per foot of diameter; that is, instead of $\frac{1}{7}$ of the diameter, the addition is $\frac{1}{3}$ of $\frac{1}{7}$, or $\frac{1}{21}$ of the product, which is at the rate of $\frac{9}{16}$ inch per foot of the product.

To find the diameter of a circle when the circumference is given—Multiply the length of the circumference by the decimal .3183; the product is the diameter.

Or, divide the circumference by 3.1416; the quotient is the diameter.

Or, multiply the circumference by 7, and divide the product by 22; the quotient is the diameter, very nearly.

To find the area of a circle.—Square the diameter—that is to say, multiply the diameter by itself, say, in inches—and multiply the product by the decimal .7854. The product is the area of the circle in square inches.

To find the length of an arc of a circle.—From 8 times the chord, A D, Fig. 17, of half the arc A D E, subtract the chord of the whole arc, A E, and divide the remainder by 3. The quotient is the eighth of the arc, nearly.

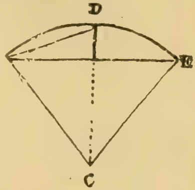


Fig. 17.

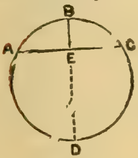


Fig. 18.

To find the diameter when the chord of an arc and the versed sine are given.—Divide the square of half the chord by the versed sine, and to the product add the versed sine. The sum is the diameter.

Note.—The versed sine is the height of the arc.

To find the area of a segment of a ring.—Multiply half the sum of the bounding arcs by their distance apart; the product is the area. Thus, let the arc A X D be 90 inches long, and the arc B C 40 inches long, and the distance A B or C D 18 inches long; then $90'' + 40'' = 130$; and $130 \div 2 = 65$; and $65 \times 18'' = 1170$ square inches, the area.

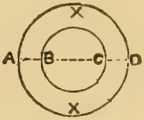


Fig. 19.

To find the area of a segment of a circle.—To ⅔ of the product of the chord A B and versed ine C D of the segment, add the cube of the versed sine divided by twice the chord; and the sum is the area, nearly. Thus—

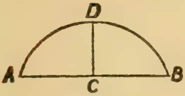


Fig. 20.

Given the chord A B as 20 inches, and the versed sine 3 inches; required the area. $20 \times 3 = 60$; and $60 \times 2 \div 3 = 40$. Then 3 inches cubed $= 3 \times 3 \times 3 = 9 \times 3 = 27$;

and $27 \div (20 \times 2) = .675$; and $.675 + 40 = 40.675$ = area nearly.

When the segment is greater than a semicircle, find the area of the remaining segment and deduct it from the area of the whole circle, the remainder is the area of the segment.

To find the area of a sector of a circle.—Multiply half the length of the arc by the radius of the circle. The product is the area of the sector. See Fig. 17.

To find the circumference of an ellipse.—Add the two diameters together; divide the sum by 2, and multiply the quotient by 3.1416. Or, multiply the sum of the two diameters by 1.5708. The product in either process, is the circumference, nearly. Thus—what is the circumference of an ellipse of which the diameters are 10 and 14? $14 + 10 = 24$; and $24 \times 1.5708 = 37.6992$; or, $10 + 14 = 24$; and $24 \div 2 = 12$; and $12 \times 3.1416 = 37.6992$ = the circumference of the ellipse.

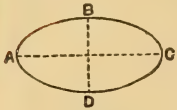


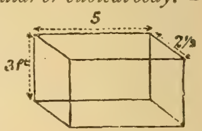
Fig. 21.

To find the area of an ellipse.—Multiply the two diameters together, and multiply the product by .7854. The final product is the area.

To find the area of a square.—Multiply the length of one side by itself, or square the side. The product is the area. For example, a square has each side 12 inches long; what is the area? $12 \times 12 = 144$ square inches is the area of the square.

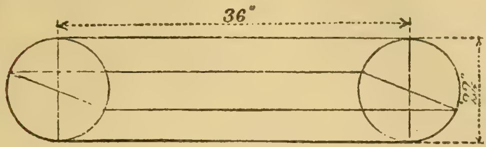
To find the area of a rectangle.—Multiply the length by the breadth; the product is the area. For example, a rectangular plate is 24 inches long and 12 inches wide; what is the area? $24 \times 12 = 288$ square inches.

To find the cubic content of a rectangular or cubical body.—Multiply the length by the breadth, and multiply the product by the depth. The last product is the cubic content. For example, a box or cistern is 5 feet long, 2½ feet wide, and 3 feet deep; what is the cubic content? 5 feet multiplied by 2½ feet makes an area of 12½ square feet; and 12½ feet multiplied by three is equal to 37½ cubic feet.



22.

To find the cubic content of a square-ended cylinder.—Find the area of one end by the rule for the area of a circle, and multiply the area by the length. The product is the cubic content of the cylinder.



·Fig. 23.

Note.—The dimensions are to be taken all in inches or all in feet. The square measure and the cubic measure, correspondingly, will be in inches or in feet.

Example.—A cylinder is 22 inches in diameter and 36 inches in length; what is the cubic content?

```
22 inches.     .7854
22               484
——           ———————
44             31416
44            62832
——           31416
484          ———————
——          380.1336 square inches, area of the end.
                  36
             ———————
            22808016
           11404008
           —————————
          13684.8096 cubic inches, solid content.
```

To find the area of a triangle.—Multiply the length of the base A B by the perpendicular height C D, and divide the product by 2. The quotient is the area of the triangle.

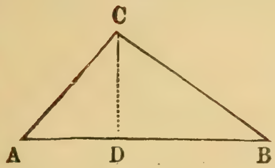


Fig. 24

When the triangle is equilateral, or equal sided, the area may be calculated by squaring the side, dividing the square by 4, and multiplying by 1.732.

To find the cubic content of a sphere.—Multiply the cube of the diameter by the decimal .5236; the product is the cubic content. For example, let the diameter be 12 inches. The cube of 12, or $12 \times 12 \times 12 = 1728$, and $1728 \times .5236 = 904.78$ cubic inches.

To find the content of a segment of a sphere.—Square the radius, or half diameter, of the base, and multiply the square by 3. To the product add the square of the height of the segment, and multiply the sum by the height and by the decimal .5236. The product is the content of the segment.

To find the content of a frustum of a cone.—Square the diameter of each end, and multiply one diameter by the other; add together the two squares and the product, and multiply the sum by the height of the frustum and by .2618. The final product is the content.

To find the content of a frustum of a square pyramid.—Add together the areas of the two ends and the product of the lengths of side of the ends; multiply the sum of the height, and divide the product by 3.

PRACTICAL GEOMETRY FOR MECHANICS, ENGINEERS, BOILER-MAKERS, ETC.

To bisect a given right line.—That is, to divide it, or square it across in two equal parts. Let A B, Fig. 25, be the given right line.

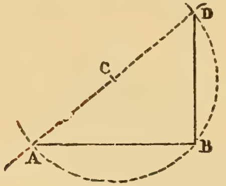


Fig 26.

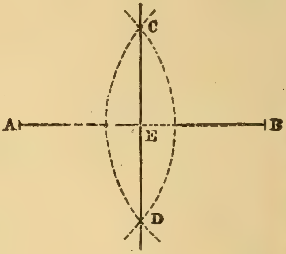


Fig. 25.

Then, with any radius greater than A E—that is greater than half the length of the line—and on A and B, as centers, describe two arcs cutting each other at C and D; draw the line C E D through the intersections. Then C E D will be at right angles to A E, and the line A B is divided into two equal parts at E.

To draw a perpendicular to a straight line from one of its extremities.—Let A B, Fig. 26, be the given line, and B the extremity from which the perpendicular is to be drawn. Take any point, C, and with the radius C B describe an arc of a circle, A B D; draw a line from A, through C, cutting the arc at D: then, a line drawn through the intersection at D from B will be perpendicular to A B.

To draw a perpendicular to a right line from a point without the line; that is, when the point is not on the line. Let A B, Fig. 27, be the given line, and C the point through which the perpendicular is to be drawn. Then, on C as a center, with any radius greater than the distance to the line A B, describe an arc cutting A B at E and D; and on E and D as centers, with any radius greater than E D, describe two arcs cutting each other at F E; a line drawn through F and C will be perpendicular to A B.

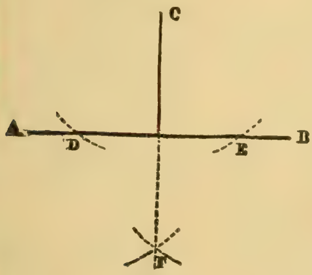


Fig. 27.

To draw a line parallel to a given straight line.—FIRST, to draw the parallel at a given distance. Let A B, Fig. 28, be the given line. Open the compasses to the distance required, and from any two points, C and D, describe arcs E and F. Draw the line G H, touching the arcs. It is the required parallel.

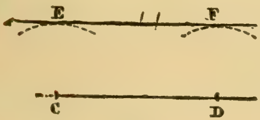


Fig. 28.

SECOND, to draw a parallel through a given point. Let C, Fig. 29, be the point. From C draw any line C D to A B. On C D, as centers, describe arcs D E and C F. Cut off D E equal to C F, and through the points C and E draw the parallel G H.

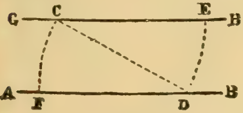


Fig. 29

To draw a rectangle from the center lines.—Draw the line A B, Fig. 30, equal to one of the center lines, bisect it at C, draw the other center line, D E, through C, at right angles to A B; then with C D as a radius, and on B and A as centers, describe arcs at H, J, F, and G; again with C A as radius, on E and D as centers, describe arcs cutting the arcs at H, J, F, and G. Join the intersections by straight lines, these will be at right angles and will form a rectangle.

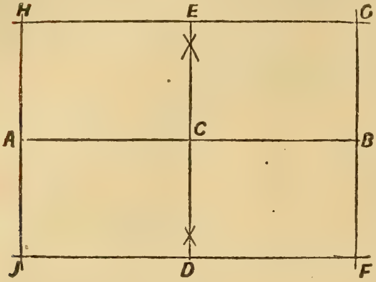


Fig. 30.

To draw a square on a given line.—Let A B, Fig. 31, be the given line. Erect a perpendicular at B, and on B as a center, with B A as a radius, describe an arc at D, and on D as a center describe another arc at C. On A as a center, with the same radius describe an arc cutting the other arc at C. Join the intersections by straight lines, and the square is formed. If truly square, it should measure the same length in the two diagonal directions; that is, the distance A D should be equal to the distance B C.

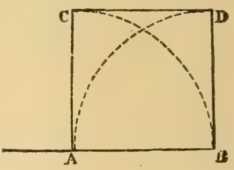


Fig. 31.

To bisect an angle.—That is, to divide it in two equal angles. On the point of the angle, A, Fig. 32, as a center, with any radius, describe an arc cutting the sides of the angle at D and E, and on D and E as centers, describe two arcs cutting each other at F. The line drawn through A and F will bisect the angle.

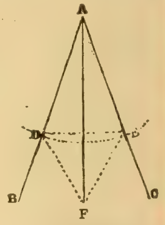


Fig 32.

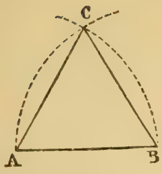


Fig. 33.

Upon a given right line to construct an equilateral triangle.—Let A. B, Fig. 33, be the given right line; then on A and B, with A B as radius, describe two arcs cutting each other at C, join A C and B C, and the triangle A B C, thus formed, is an equilateral triangle.

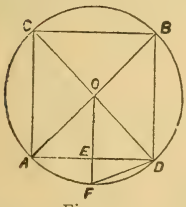


Fig. 34.

In a given circle to inscribe a square.—Draw any two diameters at right angles to each other, and join the extremities, as in Fig. 34.

To inscribe an octagon.—First inscribe the square, then bisect the quarter circles and join the extremities. Or, bisect the angle A O D, Fig. 34, by the line O F. Then D F is the length of the side of the octagon.

To draw a circle through three given points, no matter how they may are placed.—

This is a very useful problem, as it enables any one to determine the diameter of the circle of which an arc is a part. Place the three points, 1, 2, 3, anywhere. With any radius greater than half the distance between two of the points, 1 and 2, and on these points as centers, describe two arcs cutting each other at A and B. Similarly, describe intersecting arcs on the points 2 and 3 as centers. Draw straight lines through the intersections respectively, meeting at O. Then O is the center from which the arc is to be described, with the radius O I, which will pass through all the three points.

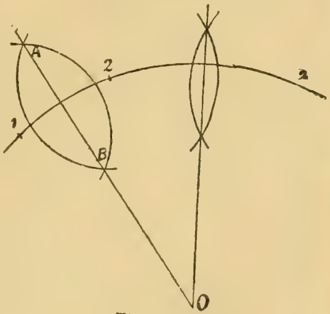


Fig. 35.

To draw a straight line equal in length to a given arc of a circle.—Divide the chord A B into four equal parts; set off one of these parts from B to C, and join C D. The line C D is equal to the length of half the given arc nearly.

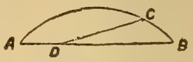


Fig. 36.

To describe a rectangle when the length of the diagonal and that of one of the ends is given.—Draw the diagonal A B. Bisect it at the center O, and with O A as radius, describe a circle. Set off the length of the end from A, cutting the circle at D, and from B cutting the circle at C, and join A C, C B, B D, and D A, to form the rectangle required.

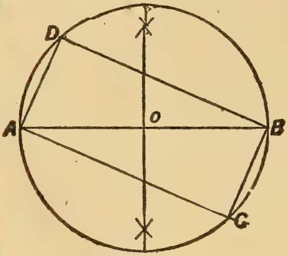


Fig. 37.

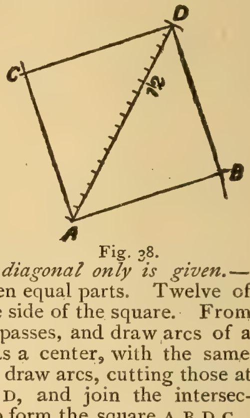


Fig. 38.

To construct a square whose diagonal only is given.—Divide the diagonal into seventeen equal parts. Twelve of these parts are the measure of the side of the square. From A take up twelve parts in the compasses, and draw arcs of a circle at B and at C; and on D as a center, with the same radius, draw arcs, cutting those at C and D, and join the intersections to form the square A B D C.

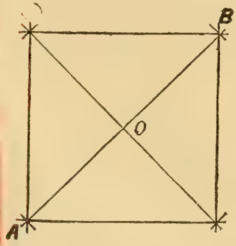


Fig. 39.

Another method.—Bisect the diagonal at O, by the perpendicular line C D; and on the center O and with the radius O B, describe arcs at C and D. Join the intersections to form the square A C B D.

To draw a square equal in area to a given circle.—Divide the diameter A B into fourteen equal parts: set off eleven of these from A to O,

and from O draw the perpendicular O C, cutting the circle at C; and draw A C. Then A C is the side of a square of which the area is equal to that of the circle. To complete the square, from C draw a line through the center of the circle, cutting the circumference at E; and from A draw the straight line A E F, through the point E. This line is at right angles to A C. With the radius A C, and on A as a center, describe an arc at F; and on F, with the same radius, draw an arc at G. From C, again, draw an arc cutting the former at G with the same radius. Join the intersections, and the square is completed.

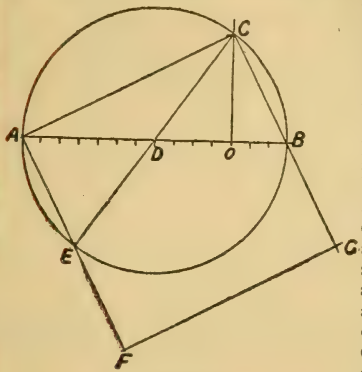


Fig. 40.

Or, multiply the diameter of the circle by .886226: the product is the side of a square of equal area.

To draw a square equal in area to a given triangle.—Let B P A be the given triangle. Draw the perpendicular P C from the summit P, and bisect it. Produce the side of the triangle B A, and set off A E equal to the half of P C. Divide E B into two equal parts at D; and on D as center, with D B as radius, describe the semicircle E B. Draw the perpendicular A F, cutting the circle at F; then A F is the side of a square equal in area to that of the given triangle.

Fig. 41.

Another method.— A right-angled triangle being given, to construct a square of the same area. Divide the diagonal into thirty-four equal parts; set off ten of these parts from

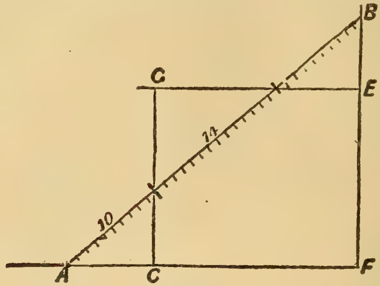


Fig. 42.

A, and ten from B, leaving fourteen in the middle. Draw G C and G E through the ten divisions, parallel to F E and C F respectively. The square C F E G has an area equal to that of the triangle A B F.

To produce a circle equal in area to a given square.— Given the square A B C D; draw the diagonals and divide

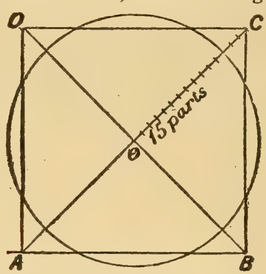


Fig. 43.

half a diagonal, O C, into fifteen equal parts. On O as center, and with a radius of twelve of these parts, describe a circle. This circle is of the same area as the square.

Or, multiply the side of the square by 1.12837. The product is the diameter of a circle equal in area to the square of which the side is given.

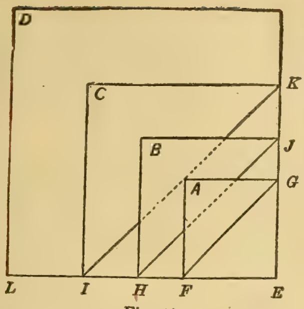


Fig. 44.

The square is divided into four triangles, each of which is one-fourth of the square in area. The quarter circles, whose figures differ of course materially from those of the triangles, have each the same area as one of the triangles.

To find the side of a square which shall contain the area of a given square any EVEN *number of times.*—Draw the given square A E. The diagonal F G is the side of a square of double the area of the given square. Set-off E H, equal to the diagonal F G; then the square E B has four times the area of the given square. Set-off again E I, equal to the diagonal H J of the square E B, and draw the square E C on that base; the square E C has twice the area of E B, or four times that of the square E A. Set off E L equal to the diagonal I K; the square E D, erected on that base, has twice the area of E C. And so on.

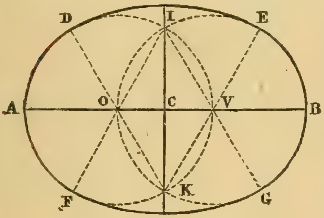


Fig. 45.

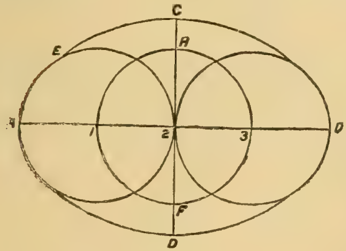


Fig. 45a.

To draw an ellipse approximately, of a given length without regard to breadth.—Divide the given length into three equal parts at O and V; and on O and V as centers, with A O as radius, describe two circles cutting each other at I and K on I and K as

with the diameter of the circle A O V as radius, describe centers arcs D E F G, to complete the form of an ellipse.

If the radius of the ends is too large and flat, divide the given length into four equal parts, Fig. 45A, and describe three circles as shown; and on H and F as centers, describe the lateral arcs to touch the first and third circles, and so complete the figure.

To draw an ellipse when the length and breadth are given—Draw the diametrical lines at right angles to each other, intersecting at O. Set out the length and breadth of the figure on these lines, equally from the center O. Set off the length O D with the compasses on the longer diameter from B to E, and on O as a center, with the radius O E, describe the

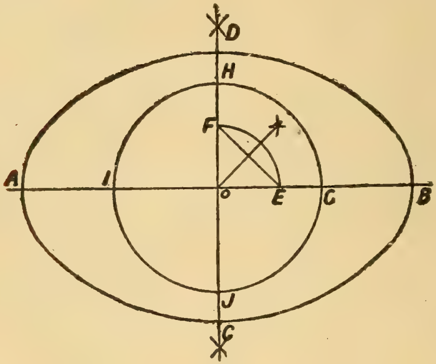


Fig. 46.

quadrant E F. Draw the line or chord E F, and set off the half of it from E to G. On O as a center, with O G as radius, describe the circle G H J I; then I and G are the centers for the segmental arcs at A and B, and H and J are the centers for the lateral arcs at C and D.'

TABLE OF SQUARE AND CUBE ROOTS.

No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.
1	1.	1.	6	2.449	1.817	42	6.481	3.476
1-16	1.031	1.020	1-4	2.5	1.832	43	6.557	3.503
1-8	1.060	1.040	1-2	2.550	1.866	44	6.633	3.530
3-16	1.089	1.059	3-4	2.599	1.890	45	6.708	3.557
1-4	1.118	1.077	7	2.646	1.913	46	6.782	3.583
5-16	1.146	1.095	1-4	2.692	1.935	47	6.856	3.609
3-8	1.173	1.112	1-2	2.739	1.957	48	6.928	3.634
7-16	1.199	1.129	3-4	2.784	1.979	49	7.	3.659
1-2	1.225	1.145	8	2.828	2.	50	7.071	3.684
9-16	1.250	1.161	1-4	2.872	2.021	51	7.141	3.708
5-8	1.275	1.176	1-2	2.915	2.041	52	7.211	3.733
11-16	1.299	1.191	3-4	2.958	2.061	53	7.280	3.756
3-4	1.323	1.205	9	3.	2.080	54	7.348	3.780
13-16	1.346	1.219	1-4	3.041	2.098	55	7.416	3.803
7-8	1.369	1.233	1-2	3.082	2.118	56	7.483	3.826
15-16	1.392	1.247	3-4	3.122	2.136	57	7.550	3.849
2	1.414	1.260	10	3.162	2.154	58	7.616	3.871
1-16	1.436	1.273	11	3.317	2.224	59	7.681	3.893
1-8	1.458	1.286	12	3.464	2.289	60	7.746	3.915
3-16	1.479	1.298	13	3.606	2.351	61	7.810	3.937
1-4	1.5	1.310	14	3.742	2.410	62	7.874	3.958
5-16	1.521	1.322	15	3.873	2.466	63	7.937	3.979
3-8	1.541	1.334	16	4.	2.520	64	8.	4.
7-16	1.561	1.346	17	4.123	2.571	65	8.062	4.021
1-2	1.581	1.358	18	4.243	2.621	66	8.124	4.041
9-16	1.600	1.369	19	4.359	2.668	67	8.185	4.061
5-8	1.620	1.380	20	4.472	2.714	68	8.246	4.082
11-16	1.639	1.391	21	4.583	2.759	69	8.307	4.102
3-4	1.658	1.402	22	4.690	2.802	70	8.367	4.121
13-16	1.677	1.412	23	4.796	2.844	71	8.426	4.141
7-8	1.695	1.422	24	4.899	2.885	72	8.485	4.160
15-16	1.714	1.432	25	5.	2.924	73	8.544	4.179
3	1.732	1.442	26	5.099	2.963	74	8.602	4.198
1-8	1.768	1.462	27	5.196	3.	75	8.660	4.217
1-4	1.803	1.482	28	5.292	3.037	76	8.718	4.236
3-8	1.837	1.5	29	5.385	3.072	77	8.775	4.254
1-2	1.871	1.518	30	5.477	3.107	78	8.832	4.273
5-8	1.904	1.535	31	5.568	3.141	79	8.888	4.291
3-4	1.936	1.553	32	5.657	3.175	80	8.944	4.309
7-8	1.968	1.570	33	5.745	3.208	81	9.	4.327
4	2.	1.587	34	5.831	3.240	82	9.056	4.345
1-4	2.061	1.619	35	5.916	3.271	83	9.110	4.362
1-2	2.121	1.651	36	6.	3.302	84	9.165	4.379
3-4	2.179	1.681	37	6.083	3.332	85	9.220	4.397
5	2.236	1.710	38	6.164	3.362	86	9.274	4.414
1-4	2.291	1.738	39	6.245	3.391	87	9.327	4.431
1-2	2.345	1.765	40	6.325	3.420	88	9.381	4.448
3-4	2.398	1.792	41	6.403	3.448	89	9.434	4.465

TABLE OF SQUARE AND CUBE ROOTS.—*Continued.*

No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.
90	9.487	4.481	138	11.747	5.167	186	13.638	5.708
91	9.539	4.498	139	11.789	5.180	187	13.674	5.718
92	9.592	4.514	140	11.832	5.192	188	13.711	5.728
93	9.644	4.531	141	11.874	5.204	189	13.747	5.738
94	9.695	4.547	142	11.916	5.217	190	13.784	5.748
95	9.747	4.563	143	11.958	5.229	191	13.820	5.758
96	9.798	4.579	144	12.	5.241	192	13.856	5.769
97	9.849	4.595	145	12.041	5.253	193	13.892	5.779
98	9.899	4.610	146	12.083	5.265	194	13.928	5.788
99	9.950	4.626	147	12.124	5.277	195	13.964	5.798
100	10.	4.641	148	12.165	5.289	196	14.	5.808
101	10.049	4.657	149	12.206	5.301	197	14.035	5.818
102	10.099	4.672	150	12.247	5.313	198	14.071	5.828
103	10.148	4.687	151	12.288	5.325	200	14.142	5.848
104	10.198	4.702	152	12.328	5.335	202	14.212	5.867
105	10.246	4.717	153	12.369	5.348	204	14.282	5.886
106	10.295	4.732	154	12.409	5.360	206	14.352	5.905
107	10.344	4.747	155	12.449	5.371	208	14.422	5.924
108	10.392	4.762	156	12.490	5.383	210	14.491	5.943
109	10.440	4.776	157	12.529	5.394	212	14.560	5.962
110	10.488	4.791	158	12.569	5.406	214	14.628	5.981
111	10.535	4.805	159	12.609	5.417	216	14.696	6.
112	10.583	4.820	160	12.649	5.428	218	14.764	6.018
113	10.630	4.834	161	12.688	5.440	220	14.832	6.036
114	10.677	4.848	162	12.727	5.451	222	14.899	6.055
115	10.723	4.862	163	12.767	5.462	224	14.966	6.073
116	10.770	4.877	164	12.806	5.473	225	15.	6.082
117	10.816	4.890	165	12.845	5.484	226	15.033	6.091
118	10.862	4.904	166	12.884	5.495	228	15.099	6.109
119	10.908	4.918	167	12.922	5.506	230	15.165	6.126
120	10.954	4.632	168	12.961	5.517	232	15.231	6.144
121	11.	4.946	169	13.	5.528	234	15.297	6.162
122	11.045	4.959	170	13.038	5.539	236	15.362	6.179
123	11.090	4.973	171	13.076	5.550	238	15.427	6.197
124	11.135	4.986	172	13.114	5.561	240	15.491	6.214
125	11.180	5.	173	13.152	5.572	242	15.556	6.231
126	11.224	5.013	174	13.190	5.582	244	15.620	6.248
127	11.269	5.026	175	13.228	5.593	246	15.684	6.265
128	11.313	5.039	176	13.266	5.604	248	15.748	6.282
129	11.357	5.052	177	13.304	5.614	250	15.811	6.299
130	11.401	5.065	178	13.341	5.625	252	15.874	6.316
131	11.455	5.078	179	13.379	5.635	254	15.937	6.333
132	11.489	5.091	180	13.416	5.646	256	16.	6.349
133	11.532	5.104	181	13.453	5.656	258	16.062	6.366
134	11.575	5.117	182	13.490	5.667	260	16.124	6.382
135	11.618	5.129	183	13.527	5.677	262	16.186	6.398
136	11.661	5.142	184	13.564	5.687	264	16.248	6.415
137	11.704	5.155	185	13.601	5.698	266	16.309	6.431

TABLE OF SQUARE AND CUBE ROOTS.—*Continued.*

No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.
268	16.370	6.447	360	18.973	7.113	500	22.360	7.937
270	16.431	6.463	361	19.	7.120	505	22.472	7.963
272	16.492	6.479	362	19.026	7.126	510	22.583	7.989
274	16.552	6.495	364	19.078	7.140	515	22.693	8.015
276	16.613	6.510	366	19.131	7.153	520	22.803	8.041
278	16.678	6.526	368	19.183	7.166	525	22.912	8.067
280	16.733	6.542	370	19.235	7.179	530	23.021	8.092
282	16.792	6.557	372	19.287	7.191	535	23.130	8.118
284	16.852	6.573	374	19.339	7.204	540	23.237	8.143
286	16.911	6.588	376	19.390	7.217	545	23.345	8.168
288	16.970	6.603	378	19.442	7.230	550	23.452	8.193
289	17.	6.610	380	19.493	7.241	555	23.558	8.217
290	17.029	6.619	382	19.544	7.225	560	23.664	8.242
292	17.088	6.634	384	19.595	7.268	565	23.769	8.267
294	17.146	6.649	386	19.646	7.281	570	23.874	8.291
296	17.204	6.664	388	19.697	7.293	575	23.979	8.315
298	17.262	6.679	390	19.748	7.306	580	24.083	8.339
300	17.320	6.694	392	19.798	7.318	585	24.186	8.363
302	17.378	6.709	394	19.849	7.331	590	24.289	8.387
304	17.435	6.723	396	19.899	7.343	595	24.392	8.410
306	17.492	6.738	398	19.949	7.355	600	24.494	8.434
308	17.549	6.753	400	20.	7.368	605	24.596	8.457
310	17.606	6.767	402	20.049	7.380	610	24.698	8.480
312	17.663	6.782	404	20.099	7.392	615	24.799	8.504
314	17.720	6.796	406	20.149	7.404	620	24.899	8.527
316	17.776	6.811	408	20.199	7.416	625	25.	8.549
318	17.832	6.825	410	20.248	7.428	630	25.099	8.572
320	17.888	6.839	412	20.297	7.441	635	25.199	8.595
322	17.944	6.854	414	20.346	7.453	640	25.298	8.617
324	18.	6.868	416	20.396	7.465	645	25.396	8.640
326	18.055	6.882	418	20.445	7.476	650	25.495	8.662
328	18.110	6.896	420	20.493	7.488	655	25.592	8.684
330	18.165	6.910	422	20.542	7.5	660	25.690	8.706
332	18.220	6.924	425	20.615	7.518	665	25.787	8.728
334	18.275	6.938	430	20.736	7.547	670	25.884	8.750
336	18.330	6.952	435	20.857	7.576	675	25.980	8.772
338	18.384	6.965	440	20.976	7.605	680	26.076	8.793
340	18.439	6.979	445	21.095	7.634	685	26.172	8.815
342	18.493	6.993	450	21.213	7.663	690	26.267	8.836
343	18.520	7.	455	21.330	7.691	695	26.362	8.857
344	18.547	7.006	460	21.447	7.719	700	26.457	8.879
346	18.601	7.020	465	21.563	7.747	705	26.551	8.900
348	18.654	7.033	470	21.679	7.774	710	26.645	8.921
350	18.708	7.047	475	21.794	7.802	715	26.739	8.942
352	18.761	7.060	480	21.908	7.829	720	26.832	8.962
354	18.814	7.074	485	22.022	7.856	725	26.925	8.983
356	18.867	7.087	490	22.135	7.883	730	27.018	9.004
358	18.920	7.100	495	22.248	7.910	735	27.110	9.024

TABLE OF SQUARE AND CUBE ROOTS.—*Continued.*

No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.	No.	Square Root.	Cube Root.
740	27.202	9.045	820	28.635	9.359	900	30.	9.654
745	27.294	9.065	825	28.722	9.378	905	30.083	9.672
750	27.386	9.085	830	28.809	9.397	910	30.166	9.690
755	27.477	9.105	835	28.896	9.416	915	30.248	9.708
760	27.568	9.125	840	28.982	9.435	920	30.331	9.725
765	27.658	9.145	845	29.068	9.454	925	30.413	9.743
770	27.748	9.165	850	29.154	9.472	930	30.496	9.761
775	27.838	9.185	855	29.240	9.491	940	30.659	9.796
780	27.928	9.205	860	29.325	9.509	950	30.822	9.830
785	28.017	9.224	865	29.410	9.528	960	30.983	9.864
790	28.106	9.244	870	29.495	9.546	970	31.144	9.898
795	28.195	9.263	875	29.580	9.564	980	31.304	9.932
800	28.284	9.283	880	29.664	9.582	990	31.464	9.966
805	28.372	9.302	885	29.748	9.600	1000	31.623	10.
810	28.460	9.321	890	29.832	9.619	1100	33.166	10.323
815	28.548	9.340	895	29.916	9.636	1200	34.641	10.627

HOW TO GEAR A LATHE FOR SCREW-CUTTING.

There is a long screw upon every screw-cutting lathe, called the lead-screw. This lead-screw feeds the carriage of the lathe while cutting screws, and has a gear wheel placed upon its end which takes motion from another gear wheel attached on the end of the spindle. Each of these gear wheels contain a different number of teeth, so that different threads may be cut. All threads are cut a certain number to the inch, from one to fifty or more. In order to gear your lathe properly to cut a certain number of threads to the inch, you will first multiply the number of threads to the inch you wish to cut by 4, or any other small number, and this will give you the proper gear to put on the lead-screw. Now, with the same number, 4, multiply the number of threads to the inch in the lead-screw, and this will give you the proper gear to put on the spindle.

Example.—You wish to cut a screw with ten threads to the inch. Multiply 10 by 4 and it will give you 40; put this gear on the lead-screw. The lead-screw on your lathe has 7 threads to the inch; multiply 7 by 4, and you will have 28. Put this gear on your spindle, and your lathe is geared to cut 10 threads to the inch.

The rule above is for those lathes which have not a stud grooved into the spindle. As this stud runs with but half the speed of the spindle, you must change the rule somewhat.

First, multiply the number of threads to the inch you wish to cut, by 4 (or some other small number), and this will give you the proper gear to put on your lead-screw. Next multiply the number of threads to the inch on your lead-screw by the same number, and *multiply this product by 2*, and this will give you the proper gear to go on your stud.

Example.—Using same numbers—10 times 4 is 40. Put this gear on your lead-screw; 7 times 4 is 28, and 2 times 28 is 56, put this gear on your stud, and your lathe is grooved to cut 10 threads to the inch.

KITCHEN AND TABLE WASTES.

Good management, both on the farm and in the household, demands that all sources of waste be guarded against and that all by-products be utilized to the best advantage. That the kitchen and table wastes are more important sources of loss than are generally realized is brought out quite strikingly by investigations made by the New Jersey authorities.

It is calculated that there could be gathered annually from 20,000 people about 2,080 tons of garbage, with an analysis and value equal to good barnyard manure. By treating with suitable solvents and drying the residue there could be secured 388½ tons of fertilizer, worth $14.69 per ton, and over 82 tons of grease, which sells for an average of $70 wherever this system is in operation. By cremation there would result 83 1-5 tons of ashes, worth $28.53 per ton.

The total population of the cities and towns of New Jersey is approximately 918,722 and the garbage of this number of people would amount to 95,516 tons per year, from which could be manufactured 17,848 tons tankage, worth $262,180, and 3,726 tons of grease. worth $260,800, a total of $522,980.

Should all this garbage be thus manipulated, there would be an increase in the plant-food supply to the extent of 45 per cent. of the tonnage of complete fertilizers used in that state during one year, which could not help but diminish the cost of fertilizers to the agriculturist.

THE THEORY OF THE STEAM ENGINE.

For many years engineers cared nothing about the theory of the steam engine. They went on improving and developing it without any assistance from men of pure science. Indeed it may be said with truth that the greatest improvement ever effected, the introduction of the compound engine, was made in spite of the physicist, who always asserted that nothing in the way of economy of fuel was to be gained by having two cylinders instead of one. In like manner, the mathematical theorist was content to make certain thermo-dynamic assumptions, and, reasoning from them, to construct a theory of the steam engine, without troubling his head to consider whether his theory was or was not consistent with practice. Within the last few years, however, the theorist and the engineer have come a good deal into contact, and the former begins at last to see that the theory of the steam engine is laid down by Rankine, Clausius, and other writers, must be deeply modified, if not entirely rewritten, before it can be made to apply in practice We have recently shown what M. Hirn, who combines in himself practical and theoretical knowledge in an unusual degree, has had to say concerning the received theory of the steam engine, and its utter inutility for practical purposes; and papers recently read before the Institutions of Mechanical and Civil Engineers, and the discussions which followed them, have done something to convince mathematicians that they have a good deal to learn yet about the laws which determine the efficiency of a steam engine. It has always been the custom to class the steam engine with other heat engines. It is now known that nothing can be more erroneous. The steam engine is a heat engine *sui generis*, and to confound it with a hot-air engine, or any motor working with a non-condensible fluid, is a grave mistake. It is not too much to say that many engineers now understand the mathematical theory of the steam engine better than do men making thermo-dynamics a special study. But there remains a large number of engineers who do not as yet quite see their way out of certain things which puzzle them, or which they fail to understand. There are, indeed, phenomena attending the use of steam which are not yet quite comprehended by any one, and we may be excused if we say something about one or two points which require elucidation.

One of these is the mode of operation of the steam jacket. It is a very crude statement that it does good because it keeps the cylinder hot. It might keep the cylinder

hot, and yet be a source of loss rather than gain ; and, as a matter of fact, it is doubtful now if the application of steam jackets to all the cylinders of a compound engine is advisable. It is well known, too, that circumstances may arise, under which the jacket is powerless for good. Thus, for example, the late Mr. Alfred Barrett, when manager of the Reading Iron Works, carried out a very interesting series of experiments with a horizontal engine, in order to test the value of the jacket. This engine had a single cylinder fitted with a very thin wrought-iron liner, between which and the cylinder was a jacket space. The jacket was very carefully drained, and could be used either with steam or air in it. Experiments were made on the brake with and without steam in the jacket. The result was a practically infinitesimal gain by using steam in the jacket. In one word, the loss by condensation was transferred from the cylinder to the jacket. On the other hand, it is well known that single cylinder condensing engines must be steam jacketed if they are to be fairly economical. Circumstances alter cases, and the circumstances which attend the use of the jackets are more complex than appears at first sight.

In considering the nature of the work to be done, we must repeat a fundamental truth which we have been the first to enunciate. A steam engine can discharge no water from it which it did not receive as water, save the small quantity which results from loss by external radiation and conduction from the cylinder, and from the performance of work. At first sight, the proposition looks as though it were untrue. Its accuracy will, however, become clear when it is carefully considered. After the engine has been fully warmed up, the cycle of events is this: Steam is admitted to the cylinder from the boiler. A portion of this is condensed. It parts with its heat to the metal with which it is in contact. The piston makes its stroke, and the pressure falls. The water mixed with the steam is then too hot for the pressure. It boils and produces steam, raising the toe of the diagram in a way well understood and needing no explanation here. During the return stroke the pressure falls to its lowest point, and the water, being again too hot for the pressure, boils, and is converted into steam, which escapes to the atmosphere or condenser without doing work, and is wasted. The metal of the cylinder, etc., falls to the same temperature as the water. At the next stroke the entering steam finds cool metal to come into contact with, and is condensed, as we have said, and so on. But the quantity condensed during the steam stroke is precisely equal to that evaporated during the

exhaust stroke, and consequently no condensed steam can leave the engine as water.

Let us suppose, for the sake of argument, however, that an engine using 20 lbs. of 100 lbs steam per horse per hour, discharges two pounds of water per horse per hour. As each of these brought, in round numbers, 1185 thermal units into the engine, and takes away only 212 units, it is clear that each pound must leave behind it 973 units; consequently the cylinder will be hotter at the end of each revolution than it was at the beginning, and the process would go on until condensation must entirely cease. It will be urged, however, that a steam jacket certainly does discharge water, and that in considerable quantity, which it did not receive; and, as this is apparently indisputable, we are here face to face with one of the puzzles to which we have referred. The fact, however, is in no wise inconsistent with what is advanced. If an engine with an unjacketed cylinder regularly receives water from the boiler, that engine will discharge precisely an equal weight of water. The liquid will pass away in suspension in the exhaust steam The engine has no power whatever of converting it into steam. The case of a jacketed engine is different. Such an engine will evaporate in the cylinder water received with the steam, but it can only do so at the expense of the steam contained in the jacket. For every 1 lb. of water boiled away in the cylinder 1 lb. of steam is condensed in the jacket; and the corollary is that, if an engine were supplied with perfectly dry steam, there would be no steam condensed in the jacket, save that required to meet the loss due to radiation and the conversion of heat into work. The effect of the jacket will be to boil a portion of the water during the close of the stroke, and so to keep up the toe of the diagram, and so get more work out of the steam. If, however, the steam was delivered wet to the engine, it is very doubtful if the jacket could be productive of much economy. The water would be converted into steam during the exhaust stroke, and no equivalent would be obtained for the steam lost in the jacket.

In a good condensing engine about 3 lbs. of steam per horse per hour are condensed in the jacket. The cylinder will use, say, 15 lbs. of steam, so the total consumption is 18 lbs. per horse per hour. It is none the less a fact, although it is not generally known, that the average Lancashire boiler sends about 8 per cent. of water in the form of insensible priming with the steam. Now, 8 per cent. of 18 lbs. is 1.44 lbs., so that in this way we have nearly one-half the jacket condensation accounted for as just explained.

One horse-power represents 2,562 thermal units expended per hour, or, say, 2.6 lbs. of steam of 100 lbs. pressure condensed to less than atmospheric pressure; and 1.44 — 260 = 4.04 lbs. per horse per hour, as the necessary jacket condensation, if no water is to be found in the working cylinder at the end of each stroke. That this quantity is not condensed only proves that the water received from the boiler, or resulting from the performance of work, is not all re-evaporated.

Something still remains to be written about the true action of the steam jacket, but this we must reserve for the present. We have said enough, we think, to show that, as we have stated, the jacket has more to do than keep the cylinder hot. With jacketed engines, more than any other, it is essential that the steam should be dry. In the case of an unjacketed engine, water supplied from the boiler will pass through the engine as water, and do little harm; but, if the engine is jacketed, then the whole or part of this water will be converted into steam, especially during the period of exhaust, when it can do more good than if it were boiled away in a pot in the engine-room. This is the principal reason why such conflicting opinions are expressed concerning the value of jackets. That depends principally on the merits of the boiler.

TREATMENT OF NEW BOILERS.

No new boiler should have pressure put upon it at once. Instead, it should be heated up slowly for the first day, and whether steam is wanted or not. Long before all the joints are made, or the engine ready for steam, the boiler should be set and in working order. A slight fire should be made and the water warmed up to about blood heat only, and left to stand in that condition and cool off, and absolute pressure should proceed by very slow stages. Persons who set a boiler and then build a roaring fire under it, and get steam as soon as they can, need not be surprised to find a great many leaks developed; even if the boiler does not actually and visibly leak, an enormous strain is needlessly put upon it which cannot fail to injure it. Of all the forces engineers deal with, there are none more tremendous than expansion and contraction.

COMPARATIVE ECONOMY OF HIGH AND SLOW SPEED ENGINES.

In nearly every case where a flour mill is built, it is intended to be a permanent investment. The very nature of the milling business makes it necessary that the plant shall be built and operated, not for one, two or three years, but for a long term of years. It is the ambition of every mill owner, when he builds a mill, to make it the foundation of a permanent business, and, if he is wise, he will build such a mill and select such machinery as will prove economical, not in first cost, but in the long run. In no part of the milling plant is this more important than in the power outfit of steam mills, and, as most of the mills now being built are steam mills, the comparative economy of different kinds of steam engines becomes an important subject for consideration. No matter whether the mill is large or small, unless it is so advantageously located as regards its supply of fuel that the cost is practically nothing, any wastefulness in the consumption of fuel creates a steady drain on the earning of the mill which will seriously affect the balance of the profit and loss account, and, where fuel is expensive, may result in transferring the balance to the wrong side of the account.

In selecting a power plant, it is a mistake, frequently made, to consider the first cost of the plant as of the highest importance, and any saving in this direction as so much clear gain. Especially is this the case in flouring mills of small capacity, where the builder's capital is limited, and where the idea is to get as much mill for as little money as possible. In such case, any money borrowed from the power plant to put into the balance of the mill, is borrowed at a ruinously high rate of interest, and it is, moreover, borrowed without any chance of repayment, except by throwing out the cheap plant and substituting the higher priced and more economical one at great expense. In no way is the miller more often misled than by the claims of the builders of the high-speed automatic engines, where the name automatic is relied upon to cover a multitude of sins in the direction of low economy. In this connection, some facts from a paper by J. A. Powers are instructive:

After carefully analyzing the problem and considering the requirements of the load to be driven in electric lighting stations, which are more favorable for the high speed engines than is the case in flouring-mill work, Mr. Powers reaches the conclusion as to the different styles of

engines in the consumption of steam, as stated by engine builders:

	Steam per H. P. per hour.
High speed engines	28 to 32 lbs.
Corliss engines, non-condensing	24 to 26 lbs.
" " condensing	20 to 21 lbs.
" " compound condensing	15 to 16 lbs.

With an evaporation of eight pounds of water per pound of coal, the coal consumption would be as follows:

	Coal per H. P. per hour
High speed engine	3.50 to 4 lbs.
Corliss engines, non-condensing	3 to 3.25 lbs,
" " condensing	2.50 to 2.62 lbs.
" " compound condensing	1.87 to 2 lbs.

As the interest on the first cost of the steam plant should properly be charged against its economy, the following statement of comparative first cost is given:

High speed engine	$31 to $36 per H. P.
Corliss engines, non-condensing	42 to 46 "
" " condensing	43 to 48 "
" " compound condensing	52 to 57 "

The comparison of first cost and fuel saving is as follows:

	Cost.	Coal. Consumption.
High speed engine	100 per cent.	100 per cent.
Corliss engine, non-condensing	131 "	62 "
" " condensing	136 "	56 "
" " compound cond'g.	163 "	44 "

If the cost of coal is taken at $3 per ton and interest is figured at six per cent., which figures may be considered a fair average, the results, based on the foregoing figures, for a plant of 400 horse-power, will be as follows:

	Cost of Coal per day.	Saving in Coal over High Speed.
High speed engine	$24.75	$....
Corliss engine, non-condensing	18.90	5.85
" " condensing	15.24	9.51
" " com'd condensing	11.64	13.11
	Interest per day.	**Loss in Interest over High Speed.**
High speed engine	$2.36	$....
Corliss engine, non-condensing	3.08	.72
" " condensing	3.15	.79
" " com'd condensing	3.75	1.39

And the saving per day over the high speed engine is:

Corliss engine, non-condensing	$ 5.13
" " condensing	8.72
" " compound condensing	11.72

So far as the steam consumption is concerned, results in every-day work show that the comparison is made as favor-

able as possible for the high speed engine, for, while records of actual tests of Corliss engines show that the figures given are not understated, the average of high speed engines after running a short time is not nearly as low as thirty-two pounds per indicated horse power per hour. So far as the cost of the respective plants are concerned, we should be inclined, especially for small plants, to put the average cost of the high speed plant a little lower than that, of the Corliss a little higher, but this change would not materially affect the result so far as comparative economy is concerned.

To bring the matter in shape to fairly apply to the requirements of the average 100 barrel mill, it may be assumed that the power required will be 50 horse power. In the absence of exact data as to the cost of the high speed plant, and to give it as favorable a showing as possible, the cost of the respective plants may be stated as follows:

High speed	$1,500
Corliss, non-condensing	2,700
" condensing	3,200
" compound condensing	4,300

The economy would then be:

	Water per H. P. per hour.	Coal per H. P. per hour.
High speed	32 lbs.	4 lbs.
Corliss non-condensing	26 lbs.	3.25 lbs.
" condensing	20 lbs.	2.5 lbs.
" compound condensing	16 lbs.	2. lbs.

And with coal and rate of interest assumed as above, based on a continuous run of 280 days, 24 hours per day, the comparison is summarized as follows:

	Cost of Fuel per Year	Interest.	Total.
High speed	$2,016	$ 90	$2,106
Corliss, non-condensing	1,638	162	1,800
" condensing	1,260	192	1,452
" comp'd condensing	1,008	258	1,266

The ratio of saving to difference in cost between the high speed plant and the others, may be stated as follows:

Between high speed and Corliss			non-condensing,	25 per cent.
"	"	"	condensing	38½ "
"	"	"	comp. condens'g	30 "

Or, in other words, it would take four years to save the difference in cost using the non-condensing Corliss, a little over two and one-half years if condensing, and three and one-half years if compound condensing. In either case, the saving would be steadily continued, long after the cost of the plant had been wiped out.

RULE FOR SAFETY VALVE WEIGHTS.

There seems to be a steady demand for this rule. The following is an easily remembered formula which may be of service to some :

$$\frac{D^2 \times .7854 \times P - D\ W + F}{L} = W.$$

Now, this looks somewhat formidable to those who are not familiar with calculations in any form, but a few words and a little study will make it clear to most persons. The explanation is this :

D^2 means that the diameter of the valve is to be multiplied by the same figure. If the valve is 4″ diameter multiply it by 4. If it is 2″ multiply it by 2; if 3½″ multiply it by 3½. This is called squaring the diameter. Now multiply the sum by .7854 and observe the decimal. This gives the area, as it is called, or number of square inches in the valve exposed to pressure. Of course, the end of the valve exposed to steam has been measured — not the top of it. Now multiply the sum last found by the pressure to be carried on the boiler, say 60, if it is 60 pounds. This gives the force pressing on the bottom of the valve to blow it off its seat. Take half the weight of the lever and whole weight of valve and stem from this last sum, and then multiply by the distance from the center of the valve-stem to the center of the hole in the short end of the lever. Divide the sum so found by the whole length of the lever. Then you have the weight of the ball to go on the end to give 60 lbs. per square inch on the boiler.

This is, in brief, the rule; but it is of no earthly use to those who are not familiar with ordinary arithmetic, for they will be very likely to make serious errors in the result by mistakes in figuring.

The steamboat inspection law demands that candidates for marine licenses shall know this rule; but in many cases it would be just as useful to demand that a man should be able to jump twenty-five feet from a standstill, for those who are incompetent can learn the rule as above given, and pass muster, without being practical working engineers, while those who have mathematical abilities and practical experience also, are only affronted by such appeals to the knowledge they have of their calling.

The qualifications and abilities of engineers for their positions are in nowise determined by such trifling exercises as these.

Amount of horse power transmitted by single belts to pulleys running 100 revolutions per minute when the diameter of the driving pulley is equal to the diameter of the driven pulley.

Diameter of Pulley.	Width of Belt in Inches.							
	2	2½	3	3½	4	4½	5	6
In.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.
	.44	.54	.65	.76	.87	.98	1.09	1.31
6½	.47	.59	.71	.83	.95	1.07	1.19	1.42
7	.51	.64	.76	.89	1.01	1.14	1.27	1.53
7½	.55	.68	.82	.95	1.09	1.23	1.36	1.64
8	.58	.73	.87	1.02	1.16	1.31	1.45	1.75
8½	.62	.77	.93	1.08	1.24	1.39	1.55	1.86
9	.65	.82	.98	1.15	1.31	1.48	1.64	1.97
9½	.69	.86	1.04	1.21	1.39	1.56	1.74	2.08
10	.73	.91	1.09	1.27	1.45	1.63	1.81	2.18
11	.8	1.	1.2	1.4	1.6	1.8	2.	2.4
12	.87	1.09	1.31	1.53	1.75	1.97	2.18	2.62
13	.95	1.18	1.42	1.65	1.89	2.12	2.36	2.83
14	1.02	1.27	1.52	1.77	2.02	2.27	2.53	3.05
15	1.09	1.36	1.64	1.91	2.19	2.46	2.73	3.29
16	1.16	1.45	1.74	2.03	2.32	2.61	2.91	3.48
17	1.24	1.55	1.85	2.16	2.47	2.78	3.09	3.70
18	1.31	1.64	1.96	2.29	2.62	2.95	3.27	3.92
19	1.39	1.73	2.07	2.42	2.76	3.11	3.45	4.14
20	1.45	1.82	2.18	2.55	2.91	3.27	3.64	4.36
21	1.52	1.91	2.29	2.67	3.05	3.44	3.82	4.58
22	1.6	2.	2.4	2.8	3.2	3.6	4	4.8
23	1.67	2.09	2.51	2.93	3.35	3.75	4.18	5.02
24	3.5	4.4	5.2	7.	8.7	10.5	12.2	14.
25	3.6	4.5	5.5	7.3	9.1	10.9	12.7	14.5
26	3.8	4.7	5.7	7.6	9.5	11.3	13.2	15.1
27	3.9	4.9	5.9	7.8	9.8	11.8	13.7	15.6
28	4.1	5.1	6.1	8.1	10.2	12.2	14.3	16.3
29	4.2	5.3	6.3	8.4	10.5	12.6	14.8	16.9
30	4.4	5.4	6.6	8.7	10.9	13.1	15.3	17.4
31	4.5	5.6	6.8	9.	11.3	13.5	15.8	18.
32	4.7	5.8	7.	9.3	11.6	14.	16.3	18.6
33	4.8	6.	7.2	9.6	12.	14.4	16.8	19.2
34	4.9	6.2	7.4	9.9	12.4	14.8	17.3	19.8
35	5.1	6.4	7.6	10.2	12.7	15.3	17.9	20.4

Amount of horse power transmitted by single belts to pulleys running 100 revolutions per minute when the diameter of the driving wheel is equal to the diameter of the driven pulley.

Diameter of Pulley.	Width of Belt in Inches.							
	2	2½	3	3½	4	4½	5	6
In.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.	H. P.
36	5.2	6.5	7.8	10.5	13.1	15.7	18.3	20.9
37	5.4	6.7	8.1	10.8	13.5	16.2	18.9	21.5
38	5.5	6.9	8.3	11.	13.8	16.6	19.3	22.1
39	5.7	7.1	8.5	11.3	14.2	17.	19.9	22.7
40	5.8	7.3	8.7	11.6	14.6	17.5	20.4	23.3
42	6.1	7.6	9.2	12.2	15.3	18.2	21.4	24.3
44	6.4	8.	9.6	12.8	16.	19.2	22.4	25.6
46	6.7	8.4	10.	13.4	16.	20.1	23.4	26.8
48	7.	8.8	10.4	14.	17.4	21.	24.4	28.
50	7.2	9.	10.9	14.6	18.2	21.8	25.4	29.
54	7.8	9.8	11.8	15.6	19.6	23.6	26.4	31.2
60	8.8	10.8	13.1	17.4	21.8	26.2	30.6	34.8
66	9.6	12.	14.4	19.2	24.	28.8	33.6	38.4
72	10.4	13.	15.6	21.	26.2	31.4	36.6	41.8
78	11.4	14.2	17.	22.6	28.4	34.	30.8	45.4
84	12.2	15.2	19.4	24.4	30.6	36.4	42.8	48.6
26	3.8	4.7	5.7	7.6	9.5	11.3	13.2	15.1
27	3.9	4.9	5.9	7.8	9.8	11.8	13.7	15.6
28	4.1	5.1	6.1	8.1	10.2	12.2	14.3	16.3
29	4.2	5.3	6.3	8.4	10.5	12.6	14.8	16.9
30	4.4	5.4	6.6	8.7	10.9	13.1	15.3	17.4
31	4.5	5.6	6.8	9.	11.3	13.5	15.8	18.
32	4.7	5.8	7.	9.3	11.6	14.	16.3	18.6
33	4.8	6.	7.2	9.6	12.	14.4	16.8	19.2
34	4.9	6.2	7.4	9.9	12.4	14.8	17.3	19.8
35	5.1	6.4	7.6	10.2	12.7	15.3	17.9	20.4
36	5.2	6.5	7.8	10.5	13.1	15.7	18.3	20.9
37	5.4	6.7	8.1	10.8	13.5	16.2	18.9	21.5
38	5.5	6.9	8.3	11.	13.8	16.6	19.3	22.1
39	5.7	7.1	8.5	11.3	14.2	17.	19.9	22.7
40	5.8	7.3	8.7	11.6	14.6	17.5	20.4	23.3
42	6.1	7.6	9.2	12.2	15.3	18.2	21.4	24.3
44	6.4	8.	9.6	12.8	16.	19.2	22.4	25.6

HOW TO TRUE AN EMERY WHEEL.

An emery wheel may be trued by using a bar of rough iron or copper as a turning tool.

HOW TO FIND THE DIAMETER OF HIGH AND LOW PRESSURE CYLINDERS AT DIFFERENT PRESSURES.

The following is a table from actual practice giving the diameters of the high and low pressure cylinders at different boiler pressures, the piston speed being taken at 420 ft. minute:

Indicated horse-power.	Diam. L. P. cylinder.	Boiler pressure 45 lbs.	Boiler pressure 80 lbs.	Boiler pressure 125 lbs.
		Diam. H.P. cylinder.	Diam. H.P. cylinder.	Diam. H.P. cylinder.
10	7¼ in.	4 in.	3⅜ in.	3¼ in.
20	10	5¾	5	4½
25	11½	6½	5½	5⅛
30	12⅜	7⅛	6¼	5⅝
40	14¼	8¼	7⅛	6⅜
50	16	9¼	8	7¼
100	22½	13	11¼	10⅛
150	27⅝	16	14	12⅜

ANIMAL POWER.

Average power of a man working to the best advantage is lifting 70 lbs. 1 ft. in 1 second for 10 hours per day, or 4,200 fr. lbs. per minute, = 0.127 horse-power.

The average work of a horse in a day of 8 hours is 22,500 lbs. raised 1 ft. in 1 minute, or 0.68 of the theoretical horse-power.

A horse can only exert a theoretical horse-power for 6 hours per day.

1 indicated horse-power = 1.4 times the average power of a horse.

The strength of a horse is equivalent to that of 6 men.

HOW TO MAKE A STRONG FLANGE JOINT.

To make a flange joint that won't leak or burn out on steam pipes, mix two parts white lead to one part red lead to a stiff putty; spread on the flange evenly, and cut a liner of gauze wire — like mosquito net wire — and lay on the putty, of course cutting out the proper holes; then bring the flanges "fair," put in the bolts and turn the nuts on evenly. For a permanent joint this is A 1.

DENSITY OF WATER.

Temperature F.	Comparative Volume. Water $32^\circ = 1$.	Comparative Density. Water $32^\circ = 1$.	Weight of 1 Cubic Foot
32	1.00000	1.00000	62.418
35	0.99993	1.00007	62.422
40	0.99989	1.00011	62.425
45	0.99993	1.00007	62.422
46	1.00000	1.00000	62.418
50	1.00015	.99985	62.409
55	1.00038	.99961	62.394
60	1.00074	.99926	62.372
65	1.00119	.99881	62.344
70	1.00160	.99832	62.313
75	1.00239	.99771	62.275
80	1.00299	.99702	62.232
85	1.00379	.99622	62.182
90	1.00459	.99543	62.133
95	1.00554	.99449	62.074
100	1.00639	.99365	62.022
105	1.00739	.99260	61.960
110	1.00889	.99119	61.868
115	1.00989	.99021	61.807
120	1.01139	.98874	61.715
125	1.01239	.98808	61.654
130	1.01390	.98630	61.563
135	1.01539	.98484	61.472
140	1.01690	.98339	61.381
145	1.01839	.98194	61.291
150	1.01989	.98050	61.201
155	1.02164	.97882	61.096
160	1.02340	.97715	60.941
165	1.02589	.97477	60.843
170	1.02690	.97380	60 783
175	1.02906	.97193	60.665
180	1.03100	.97006	60.543
185	1.03300	.96828	60.430
190	1.03500	.86632	60.314
195	1.03700	.96440	60.198
200	1.03889	.96256	60.081
205	1.0414	.9602	59.937
210	1.0434	.9584	59.822
212	1.0444	.9575	59.769

CALKING STEAM BOILERS.

No well-made boiler ought to require to be heavily calked, and to provide for light calking it is imperative that the plates of a boiler should be effectually and thoroughly cleaned of all fire scale before being riveted up. Good boiler work should be very nearly tight without calking, but it is difficult to attain this degree of excellence with hand work. Hydraulic riveting, in which the plates are forcibly pressed together before the rivet is closed and made to fit the hole, will, if carefully done, be found to give a tight boiler without calking. It is obvious that tightness can only be secured by insuring metallic contact. If all the rivets fill the holes perfectly, no leakage can percolate past the rivet heads. If any rivet heads require calking, they should be cut out and a fresh rivet inserted, as a leak is a sure indication that the rivet does not fill the hole, and is possibly imperfectly closed in addition. It is also obvious that to insure a tight boiler the surfaces of the plates must be in metallic contact, and must remain so when the boiler is subjected to the working pressure which, with the alterations of temperature, will produce certain inevitable changes in the form of the boiler. It is obviously necessary that the surfaces of the plates should be smooth in order to insure metallic contact, and that this cannot be attained unless the scale covers the plates completely, or is wholly detached. As a slight pin-hole in the magnetic oxide with which steel plates are coated will cause a leakage, and under certain circumstances, set up a galvanic and corrosive action, it is advisable to wholly detach the scale. This is easily done with iron plates, but steel plates cannot be completely cleaned of magnetic oxide by the usual mechanical methods. An excellent and effective method is that used at the Crewe Works of the London & Northwestern Railway (England). The plates are brushed over with muriatic acid diluted with water, and applied with a brush or pad made with woolen waste. This

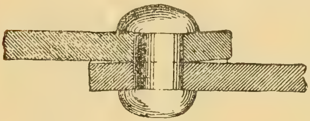


FIG. 1.

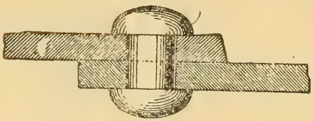


FIG. 2.

loosens and detaches all the scale, and the plates are then cleaned by a solution of lime, which effectually removes any surplus muriatic acid. If the plates are not wanted immediately, they can be protected from rust by a coat of turpentine and oil. If these precautions be not taken, the scale or dirt upon the plates becomes crushed to powder by the squeeze of the riveter, and a close metal to metal joint is rendered impossible, and the consequent leakage must be stopped by calking. With clean plates much calking is not necessary, nor should it be countenanced, for, after all, calking is only an evidence of, and a concession to, more or less inferior, or, at least, imperfect workmanship.

Some boiler-makers firmly believe that calking should be performed both internally and externally, and we may frequently hear this double calking expatiated upon as adding to the value of a boiler. As a matter of fact, however, internal calking should never be resorted to. By internal calking we mean specially to indicate the calking of edges exposed to steam or water, especially the latter, for long experience has shown, with very little room for doubt, that internal calking has frequently been either a cause or an aid in the initiation of corrosive channeling of the plates along the line of the rivet seams. Though channeling is commonly met with along the longitudinal seams, being started, more frequently than by any other cause, by the want of perfect circularity of the boiler, yet it is aggravated by the calking of the edge of the plate which borders the channeling, and the explanation is that an abnormal stress is set up in the plate upon which the calked edge is forced down, and too frequently the calking tool itself is driven so severely upon the plate surface as to cause an injury which develops as channeling when other conditions, such as bad water, etc., are present. These causes have been mainly contributory to the modern practice of outside calking only, and, with proper workmanship, this is all that should be required, but the best practice rejects any calking at all in the strict acceptation of the term, and demands that the edges of the plates shall be planed and "fullered;" fullering being the thickening up of the whole edge of the plate by means of a tool having a face equal to the plate thickness. With such a tool as this, it is impossible to wedge apart the plates forming the joint, and so frequently done in the manner shown (exaggerated) in Fig. 1, when the narrow edge of the calking tool, driven perhaps by a heavy hammer, actually forces the plates apart and insures a tight joint only by the piece of damaged plate corner which remains driven fast into the gap.

In contrast to this, Fig. 2 may be taken to fairly represent the correct action of the more correct fullering tool, the plate edge being simply thickened, and contact between the two plates rendered certain for some distance in from the edge. To thus thicken, or "fuller" a plate, requires considerable power, and yet, even the use of a more than usually heavy hammer will not cause injury, as it certainly would do in careless hands, if used with a narrow calking tool. All modern first-class boiler work in England is inviarably fullered, and, though the practice of inside calking is still followed by firms who "fuller," nevertheless, outside work is gaining the day. A further advantage of the "fulling" tool may be named. If inside calking be still practiced, the tendency to cause grooving will be less marked than with the narrow tool, and where, as at times, it is absolutely necessary to internally calk, as may sometimes happen, the last is a great point in favor of the broad tool.

The foregoing remarks are suggested by a few notes on calking in an engineering work, wherein calking tools are described as having from ⅛ to 3-16 of thickness, and "best work" as being calked both inside and out. In itself, calking properly carried out, and lightly performed on good, close-riveted joints, is not necessarily bad, but too frequently is badly performed by careless workmen and boys, and hence "fullering," which is better practice, and is also a safeguard against carelessness, is to be preferred to the old method.

HOW TO THAW OUT A FROZEN STEAM-PIPE.

A good way to thaw out a frozen-up steam pipe, is to take some old cloth, discarded clothes, waste, old carpet, or anything of that kind, and lay on the pipe to be thawed; then get some good hot water and pour it on. The cloth will hold the heat on the pipe, and thaw it out in five minutes. This holds good in any kind of a freeze, water-wheel, or anything else.

How many people, outside of practical men, know that steam is an invisible gas until the moisture it bears is condensed by contact with cold air. Such is a fact, nevertheless, as we may readily see by boiling water in a glass vessel. The bubbles that rise to the surface of the water are apparently empty — the white vapor appears after they burst in the air at the surface of the water.

THE PREVENTION OF ACCIDENTS FROM RUNNING MACHINERY.

A German commission was appointed to investigate accidents in mills and factories, and draw up a series of rules for their prevention. Some of these rules are as follows:

SHAFTING.

All work on transmissions, especially the cleaning and lubricating of shafts, bearings and pulleys, as well as the binding, lacing, shipping and unshipping of belts, must be performed only by men especially instructed in, or charged with, such labors. Females and boys are not permitted to do this work.

The lacing, binding or packing of belts, if they lie upon either shaft or pulleys during the operation, must be strictly prohibited. During the lacing and connecting of belts, strict attention is to be paid to their removal from revolving parts, either by hanging them upon a hook fastened to the ceiling, or in any other practical manner; the same applies to smaller belts, which are occasionally unshipped and run idle.

While the shafts are in motion, they are to be lubricated, or the lubricating devices examined only when observing the following rules: *a.* The person performing this labor must either do it while standing upon the floor, or by the use of *b.* Firmly located stands or steps, especially constructed for the purpose, so as to afford a good and substantial footing to the workman. *c.* Firmly constructed sliding ladders, running on bars. *d.* Sufficiently high and strong ladders, especially constructed for this purpose, which, by appropriate safeguards (hooks above or iron points below), afford security against slipping.

The cleaning and dusting of shafts, as well as of belt or rope pulleys mounted upon them, is to be performed only when they are in motion, either while the workman is standing: *a*, on the floor; or *b*, on a substantially constructed stage or steps; in either case, moreover, only by the use of suitable cleaning implements (duster, brush, etc.), provided with a handle of suitable length. The cleaning of shaft bearings, which can be done either while standing upon the floor or by the use of the safeguards mentioned above, must be done only by the use of long-handled implements. The cleaning of the shafts, while in motion, with cleaning waste or rags held in the hand, is to be strictly prohibited.

All shaft-bearings are to be provided with automatic lubricating apparatus.

Only after the engineer has given the well understood signal, plainly audible in the work-rooms, is the motive engine to be started. A similar signal shall also be given to a certain number of work-rooms, if only their part of the machinery is to be set in motion.

If any work other than the lubricating and cleaning of the shafting is to be performed while the motive engine is standing idle, the engineer is to be notified of it, and in what room or place such work is going on, and he must then allow the engine to remain idle until he has been informed by proper parties that the work is finished.

Plainly visible and easily accessible alarm apparatus shall be located at proper places in the work-rooms, to be used in cases of accident to signal to the engineer to stop the motive engine at once. This alarm apparatus shall always be in working order, and of such a nature that a plainly audible and easily understood alarm can at once be sent to the engineer in charge.

All projecting wedges, keys, set-screws, nuts, grooves, or other parts of machinery, having sharp edges, shall be substantially covered.

All belts and ropes which pass from the shafting of one story to that of another shall be guarded by fencing or casing of wood, sheet-iron or wire netting four feet six inches high.

The belts passing from shafting in the story underneath and actuating machinery in the room overhead, thereby passing through the ceiling, must be inclosed with proper casing or netting corresponding in height from the floor to the construction of the machine. When the construction of the machine does not admit of the introduction of casing, then, at least, the opening in the floor through which the belt or rope passes should be inclosed with a low casing at least four inches high.

Fixed shafts, as well as ordinary shafts, pulleys and fly-wheels, running at a little height above the floor, and being within the locality where work is performed, shall be securely covered.

These rules and regulations, intended as preventions of accidents to workmen, are to be made known by being conspicuously posted in all localities where labor is performed.

ENGINEERS.

The attendant of a motive engine is responsible for the preservation and cleaning of the engine, as well as the floor of the engine-room. The minute inspection and lubrication

of the several parts of the engine is to be done before it is set in motion. If any irregularities are observed during the performance of the engine, it is to be stopped at once, and the proper person informed of the reason.

The tightening of wedges, keys, nuts, etc., of revolving or working parts, is to be avoided as much as possible during the motion of the engine.

When large motive engines are required to be turned over the dead point by manual labor, the steam supply valve is to be shut off.

After stoppage, either for rest or other cause, the engine is to be started only after a well-understood and plainly audible signal has been given. The engineer must stop his engine at once upon receipt of an alarm signal.

The engineer has the efficient illumination of the engine-room, and especially the parts moved by the engine, under his charge.

The engineer must strictly forbid the entrance of unauthorized persons into the engine-room.

An attendant of a steam or other power motor, who is charged with the supervision of the engine as his only duty, is permitted to leave his post only after he has turned the care of the engine over to the person relieving him in the discharge of his duties.

The engineer is charged with the proper preservation of his engine, and means therefor. He must at once inform his superior of any defect noticed by him.

The engineer on duty is permitted only to wear closely fitting and buttoned garments. The wearing of aprons or neckties with loose, fluttering ends, is strictly prohibited.

GEARING.

Every work on gearing, such as cleaning and lubricating shafts, bearings, journals, pulleys and belts, as well as the tying, lacing and shipping of the latter, is to be performed only by persons either skilled in such work, or charged with doing it. Females and children are absolutely prohibited from doing such work.

When lacing, binding or repairing the belts, they must either be taken down altogether from the revolving shaft or pulley, or be kept clear of them in an appropriate manner. Belts unshipped for other reasons are to be treated in the same manner.

The lubricating of bearings and the inspection of lubricating apparatus must, when the shafting is in motion, be performed either while standing upon the floor or by the use

of steps or ladders, specially adapted for this purpose, or proper staging or sliding ladders. The lubrication of wheel work and the greasing of belts and ropes with solid lubricants is absolutely prohibited during the motion of the parts.

In case of accident, any workman is authorized to sound the alarm signal at once by the use of the apparatus located in the room for this purpose, to the engineer in charge.

The following rules, classified under proper sub-heads, are published by the *Technische Verein*, at Augsburg:

TO PREVENT ACCIDENT BY THE SHAFTING.

While the shafts are in motion, it is strictly prohibited: *a.* To approach them with waste or rags, in order to clean them. *b.* In order to clean them, to raise above the floor by means of a ladder or other convenience.

It is allowable to clean the shafting and pulleys only while in motion.

These parts of the machinery must be cleaned by means of a long-handled brush only, and while standing upon the floor.

The workmen charged with these or other functions about the shafting must wear jackets with tight sleeves, and closely buttoned up; they must wear neither aprons nor neckties with loose ends.

Driving pulleys, couplings and bearings are to be cleaned only when at rest.

This labor should, in general, be performed only after the close of the day's work. If performed during the time of an accidental idleness of the machinery, or during the time of rest, or in the morning before the commencement of work, the engineer in charge is to be informed.

HOW TO FIND THE HORSE-POWER OF AN ENGINE.

Multiply the square of the diameter of the cylinder by 0.7854, and, if the cut-off is not known, multiply the product by four-fifths of the boiler pressure; multiply the last product by the speed of the piston in feet per minute (or twice the stroke in feet and decimals, multiplied by the revolutions per minute). Divide the final product by 33.000. and the horse-power will be the answer.

ECONOMY IN THE USE OF AN INJECTOR.

The following is an interesting discussion of the economy due to the use of an injector, in comparison with a direct-acting steam-pump, both with and without a feed-water heater, and a geared pump with heater. Although the investigation is theoretical, it seems to be based on reliable data, so that the results, as summarized in the following table, differ little, in all probability, from the figures which would be obtained by actual experiment :

Manner of feeding boiler.	Temperature of feed-water. Fahrenheit.	Relative amount of coal required for feed apparatus, in equal times.	Per cent. of fuel saved over first case.
1. Direct-acting steam-pump, no heater.....	60°	100	0.
2. Injector, no heater	150°	98.5	1.5
3. Injector, with heater........	200°	93.8	6.2
4. Direct-acting steam-pump, with heater...	200°	87.9	12.1
5. Geared-pump, actuated by the main engine, with heater.......	200°	86.8	13.8

This does not make the comparison between the economical performance of an injector and pump actuated by the main engine, without heater in each case, or, in other words, he does not consider one of the most general divisions of the problem. Some experiments made on the Illinois Central Railroad may be briefly cited to supplement the discussion. The figures given represent averages of eight trips of 128 miles in each case:

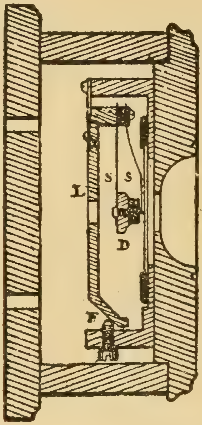
	Feeding with pump.	Feeding with injector.	Per cent. of grain for injector
Pounds of coal per trip...	9,529	8,736	9.08
Pounds of water per trip.	48,888	46,826	4.04
Pounds of water evaporated per pound of coal	5.14	5.26	4.28

In the experiments with pump, the trains were slightly heavier than when the injector was used, and more time was

lost in switching and standing, for which reason the experimenters considered that the economy of coal consumption for the injector should be reduced from 9.08 to 6.21 per cent. Some incidental advantages were observed in the case of the injector, the boiler steamed more freely, and there was less variation of pressure.

TELEPHONES.

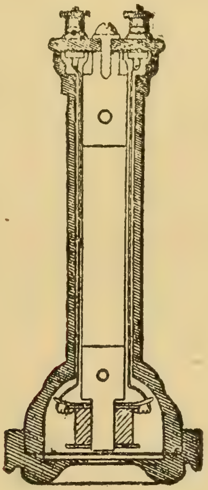
Telephones are of two kinds—magneto and electric. In one sense of the word they both work on the same principle, namely: A series of pulsations, corresponding in length and



SECTION OF A BLAKE TRANSMITTER

strength to the sound waves made by the voice, cause similar pulsations in the receiving end of the telephone circuit, and these pulsations in turn make sound waves which reach the ear. Magnetism and electricity work together in a telephone. If a wire is moved just in front of the poles of a magnet, whether it be an electro or a permanent magnet, a current of electricity is induced in the wire. If a current of electricity is set to flowing around a piece of soft iron, that

piece of iron becomes an electro-magnet and remains as such as long as the electricity flows around it. A steel magnet, however, is always a magnet unless particular pains are taken to de-magnetize it. Around every magnet is a magnetic field, and the field is traversed by what are known as lines of force. Any change in the lines of force induce electricity, and this is the bottom principle in the working part of a telephone. In the receiver of a telephone of the Bell pat-



SECTION OF A BELL RECEIVER.

tern is a bar or straight permanent magnet. At one end of this bar-magnet is an electro-magnet. Two small copper wires lead back from the electro-magnet to the closed end of the receiver and the diaphragm of the telephone fits into the case so near the poles of the electro-magnet as to almost touch it. This is a magneto-telephone, and such telephones are usually used as receivers. When the diaphragm is moved back and forth by sound waves, it cuts the lines of force in the magnetic field and induces undulatory currents

of electricity, which are transmitted by the telephone wire to the other telephone. In practice, however, the undulatory currents are induced by the transmitter which is an electric telephone. The most common type of transmitter in the United States is the Blake. In this transmitter the working parts are the diaphragm; touching it is a platinum bottom which in turn rests lightly against a carbon button. The current of electricity flows through the carbon button, then through the platinum bottom and so out to the wires. When the diagraphragm, vibrating on account of the sound waves of the voice, presses against the platinum bottom, it in turn presses against the carbon button giving it a succession of little squeezes which make the current of electricity stronger or weaker, thus producing an unduiatory current. The undulations carried over the wires affect the magnet in the receiving telephone, causing the diaphragm to respond, thus reproducing speech at that end of the telephone circuit.

RAPID RAILWAY TRANSIT.

As an illustration of the speed at which railway traveling can be effected wnen the necessity arises, it may be mentioned that an American having missed the train in London, and having to catch an Atlantic steamer at Liverpool, proceeded by the ordinary train to Crewe, where a special engine had been chartered to convey him direct to Liverpool. The distance between Crewe and Liverpool is 36 miles, and one of the large Crewe engines completed the journey in 33 minutes, reaching the landing stage at Liverpool 10 minutes before the timed departure of his steamer.

USEFUL CEMENTS.

A cement said to resist petroleum is made by taking three parts resin, one part caustic soda to five of water, boiled together, the resin being melted first, of course. This makes a resin soap, to which must be added half its weigh of plaster. It hardens in forty minutes. Useful for uniting lamp tops to glass, Glycerine and litharge, mixed thoroughly, is said to form a cement which hardens rapidly, and will join iron to iron or iron to stone. Not affected by water or acids.

A cement for leaky roofs is made by the following articles

in the proportions named: 4 pounds resin, 1 pint linseed oil, 2 ounces red lead; stir in finest white sand until of the proper consistency, and apply hot. It possesses elasticity, and is fireproof.

Starch and chloride of zinc form a cement which hardens quickly, and is durable. Sometimes used for stopping blow-holes in castings.

A cement for uniting metal to glass is made with 2 ounces thick solution of glue, 1 ounce linseed oil varnish. Stir and boil thoroughly. The pieces should be tied together for three days.

A cement of 100 parts each white sand, litharge and limestone, combined with 7 parts of linseed oil, makes the strongest mineral cement known. At first the mass is soft and of little coherence, but in six months' time it will, if pressed, become so hard as to strike fire from steel.

A free application of soft soap to a fresh burn almost instantly removes the fire from the flesh. If the injury is very severe, as soon as the pain ceases apply linseed oil, and then dust over with fine flour. When this covering dries hard, repeat the oil and flour dressing until a good coating is obtained. When the latter dries, allow it to stand until it cracks and falls off, as it will in a day or two, and a new skin will be found to have formed where the skin was burned.

A new form of electrical railway is being erected at St. Paul, Minn. The cars do not touch the ground, but are suspended from girders which form the track and at the same time the mains conveying the current. Speeds of from eight to ten miles per hour are expected.

CELLULOID SHEATHING.

Among the various uses of celluloid, it would appear to be a suitable sheathing for ships, in place of copper. A French company now undertakes to supply the substance for this at nine francs per surface meter, and per millimeter of thickness. In experiments by M. Butaine, plates of celluloid applied to various vessels in January last, were removed five or six months after, and found quite intact and free from marine vegetation, which was abundant on parts uncovered. The color of the substance is indestructible; the thickness may be reduced to 0.0003 meter; and the qualities of elasticity, solidity and impermeability, resistance to chemical action, etc., are all in favor of the use of celluloid.

TRANSMITTING POWER BY A VACUUM.

The idea of producing a vacuum in a receiver or in a system of pipes, and utilizing this vacuum to transmit power, was put forth many years ago. In an article published in 1688 Papin recommends the use of this mode of transmission. He mentions its advantages, particularly its simplicity and convenience; he gives for different cases, the proper diameters of the pipes in which the vacuum is made, and recommends lead as the material from which to make them. The idea is therefore old, but it is only recently that it has been put into practice. There is now a central station running on this principle in Paris, distributing 250 h. p. by means of pipes in which a seventy-five per cent. vacuum is maintained. One year ago the company running this station had fifty customers; now there are 105 leases signed.

The possibility of maintaining a vacuum in an extensive system of pipes has sometimes been questioned. Repeated experiments, however, have shown that in a line of pipes a third of a mile long a pressure of a quarter of an atmosphere can be maintained so that two gauges, one at each end of the pipe, stand at exactly the same point.

In the station at Paris the exhauster is operated by a Corliss engine of special construction, the speed of which is automatically controlled by a regulator operated by the variations in pressure in the main pipe. The branch pipes are of lead, and are of different diameters, according to the number of consumers that each is to supply. Each of these branch pipes is provided with a cock that can be opened or closed by means of a wrench that is kept at the central station. The smaller branches that supply the individual customers are also of lead, and are likewise provided with cocks that can be opened or closed only by the employés of the company, who retain possession of the wrenches that open them.

Two kinds of motors are in use, one, the rotary class, being used for the smaller powers; the other class, which have cylinders and pistons, being used only for larger powers. The small motors have an efficiency of about 40 per cent., while in the largest size the efficiency is said to be as high as 80 per cent.

SPONTANEOUS COMBUSTION.

No one of average intelligence and information now believes in the possibility of human beings or the lower animals undergoing spontaneous combustion; and yet it is barely forty years since Liebig devoted a long chapter of his

celebrated "Familiar Letters on Chemistry" to exposing the fallacy of this idea, thus showing that at that date it was prevalent. Every reader of Dickens will remember that in one of his most interesting stories an important episode is made to turn on the popular belief in spontaneous combustion, a belief which Dickens himself would seem to have shared. Of course, as Liebig points out, it requires no explanation to account for the connection which has often been shown to exist between death by burning and the too frequent indulgence of ardent spirits. Spontaneous combustion, though not of living animals, may, however, occur in certain cases, and give rise to fires in buildings, etc., and it may, therefore, be of interest to the reader to examine shortly some of those possible cases and their causes. But first of all, a few words as to "combustion" itself, the true nature of which was explained by the famous French chemist Lavoisier, toward the end of last century.

An act of combustion is an act of chemical combination attended by the evolution of heat and light, and, for such an act, two conditions are necessary, viz.: (1) There must be a gas in which the given substance will burn, *i. e.* with which it will combine chemically, and (2) there must be a certain temperature, the degree of temperature being different for each different substance. Thus, to take only one common example, a piece of coal will remain unaltered, at the ordinary temperature of the air, for practically an unlimited period of time; but, if it be heated to a sufficiently high temperature, it will burn. *i. e.*, the carbon of which it is composed will combine with the oxygen of the air, to form carbonic acid gas; chemical combination goes on in this case so rapidly, comparatively speaking, that the heat and light set free by it are palpable to our senses. Now, the two requisite conditions just mentioned sometimes occur together in nature, giving rise to true cases of spontaneous combustion, of which the following examples may be cited:

1. The *ignis fatuus*, or "will-o'-the-wisp," is the effect of the spontaneous ignition of a volatile compound of phosphorus and hydrogen, which is generated, under certain conditions, from decomposing animal and vegetable matter. This compound has such an intense affinity for the oxygen of the air, that, the moment it comes in contact with the latter, it ignites of itself, giving out the flash of light that has deluded so many a wanderer.

2. Spontaneous combustion also occurs not unfrequently in coal ships, or in the coal bunkers of ordinary vessels. Coal generally contains iron pyrites or "coal brasses" disseminated

through it, and this pyrites, which is a compound of iron and sulphur, has a great tendency to absorb oxygen from the air and to combine with it, forming sulphate of iron, or "green vitriol." This absorption and combination are accompanied by a rise of temperature, and they sometimes go on so rapidly as to raise the temperature of the mass sufficiently high to cause the coal to catch fire.

3. Fires in buildings are often to be traced to the presence of heaps of old cotton waste. Such waste is always more or less impregnated with oil, and, being very loose in texture, it exposes a large surface to the air. The result is that the oil rapidly absorbs and combines chemically with the oxygen of the air, just as the pyrites in coal does, raising the temperature to such a degree that a fire ensues.

4. The "heating of corn which has been stacked before the sheaves have been sufficiently dried, and which sometimes ends in the corn stack catching fire, is the result of chemical changes of the nature of fermentation.

5. Every one must have observed what a large amount of heat is set free when lime is slacked — so much, indeed, that fires have frequently been known to result from it. The reason of this is, that the lime combines with a certain proportion of water, this act of combination causing much heat to be liberated.

The above instances are sufficient to show that spontaneous combustion in no way differs from ordinary combustion, excepting in that the requisite temperature is attained by natural causes, and not artificially, and that the old idea held by the superstitions of last century, that the spontaneous combustion of animals (which we now know to be impossible) was caused by a peculiar kind of fire, differing from ordinary fire, and not extinguishable by water, was the result of ignorance. There is still one other cause of spontaneous combustion, often very dangerous in its effects, and which leads us on to the subject of explosions, which must be mentioned here. One occasionally reads in the newspapers of explosions occurring in flour mills, sometimes from no apparent cause. These explosions are cases of rapid spontaneous combustion, in which a spark from the grindstone sets fire to the fine flour dust with which the air of the mill is impregnated.

But what is an "explosion"? An explosion is nothing more nor less than a combustion which spreads with great rapidity throughout the whole mass of the combustible matter. To our senses it appears to be instantaneous, but it is not really so. An example will make this clear. A mixture of hydrogen

and oxygen, or hydrogen and air, is a highly dangerous one, because the instant that a light is introduced into it it explodes; that is to say, the particles of hydrogen and oxygen in the immediate neighborhood of the flame are raised to the requisite temperature at which chemical combination can take place between them. They therefore do combine to form water vapor, and, by doing so, give out heat enough to cause combination between the particles next to them, and so on throughout the whole mass of the gas. This action goes on, as already stated, so rapidly as to be practically instantaneous. The terrible effects of explosions are caused, then, by the sudden production of immense quantities of hot gases. The newspapers constantly tell us of disastrous explosions resulting from the bringing of a light into a room in which an escape of gas is going on. A mixture of coal gas and air behaves in precisely the same manner as the mixture of hydrogen and oxygen, or hydrogen and air, mentioned above, with the exception that the products of the combustion or explosion are different. When an escape of gas is suspected, all lights should be rigorously excluded, the gas turned off at the meter or main, and windows and doors opened, so as to get rid of the already-escaped gas as quickly as possible; and only then, after complete ventilation has taken place, may a light be brought into the room with safety. It is to be hoped that such a technical instruction bill will soon be passed by parliament as will render avoidable accidents of this nature less and less likely to occur. It is likewise a dangerous thing to blow out a paraffine lamp instead of turning the wick down, as, by blowing the flame downward, one is apt to ignite the mixture of oil, gas and air which is in the upper portion of the oil reservoir, and so to produce a serious explosion.

The explosion caused by the ignition of gunpowder or any other ordinary explosive, is explicable in the same way, but can only be touched upon in this article. Gunpowder is a most intimate mixture of charcoal, sulphur and nitre (potassic nitre), the last named substance being a compound containing a very large percentage of oxygen, which can be liberated on heating it. On applying a light to gunpowder, we raise the temperature sufficiently to allow of the carbon and sulphur burning in the oxygen liberated from the nitre; and, since the three substances are so intimately mixed together, this combustion proceeds with explosive rapidity, and produces a relatively enormous quantity of hot gas.

Steel, when hardened, decreases in specific gravity, contracts in length and increases in diameter.

RULES FOR THE FIREMAN.

In the care and management of the steam boiler the first thing required is an unceasing watchfulness — *watch-care* is the very word which describes it. The accidents arising from neglect or incompetency in care of the engine are few and unimportant compared to those which come from negligence in attending to the boiler.

Hence the fireman needs to be a man possessed of some of the highest qualities of manhood. The fact that many of the best steam engineers in the country have begun their careers by handling the shovel is evidence that good men are required and employed in this capacity, and that they are rewarded for their faithfulness by advancement.

An intemperate, reckless or indifferent man should never be given this place of trust. The sooner a man is dismissed who is either of these the better, both for himself and his employers, to say nothing of the innocent and unsuspecting public.

An employer should know something of the character and habits of the man who does the firing. A daily visit, and, at irregular times, with an eye to things in *the boiler-room*, as well as the engine-room, will keep him posted, to his great advantage. This regular inspection is most welcome to faithful and careful men, and is a great inspiration to good service. A steam-user should visit his steam department as regularly as he does his office, although he may not spend as much time there. The failure of scores of otherwise flourishing establishments is due to the waste and recklessness in the use of fuel under the boilers, or the heavy losses incurred by repairs and explosions — by which the whole business is stopped while the expenses continue undiminished.

A feeling of conscientious responsibility should be the uppermost thing upon the mind of a fireman when on duty. He should consider and know how to figure the total tons of pressure upon the plates of his boiler, and have constantly in mind the importance of unceasing vigilance.

To know how to be a good fireman cannot be taught by a book. The knowledge comes by experience and by instruction of engineers who have themselves been good firemen, but the following are some of the hints and rules which may be of advantage to the new beginner.

First — The fireman should be a sober and temperate person. Frivolous or reckless conduct about a steam-boiler is entirely out of place, and should not be permitted. There

is too much danger and too much cost — not to call it waste — of fuel to allow any indifference or recklessness in the man upon whom so many depend.

Second — The fireman should be punctual in beginning his work. A loss of five minutes in starting into vigorous activity the men and machines of an establishment is sometimes caused by inattention of the fireman, and the blame which is showered upon him is a stern reminder that he is held accountable for the loss.

Third — A habit of neatness is an almost necessary quality, and which pays better for the cost of investment than any other.

Fourth — The tools should be kept in their places, and in good order.

Fifth — The boiler and all its attachments should be kept in the very tidiest and attractive condition possible.

Sixth — The fireman, notwithstanding its apparent difficulty, should keep himself — as said once — "respectable about his work." Scattered coal and ashes and dripping oil should be constantly cleaned up, and every effort made to make the boiler-room an attractive and cheerful place.

Seventh — The fireman needs to know all the details of his work, and to do with exactness every duty imposed upon him. He needs to be cool and brave in the presence of unexpected conditions, such as sudden leaks, breakages of the glass gauges and sudden stoppages of the engine with a heavy head of steam on.

Eighth — He should have an idea of the importance of his work, and keep in mind to learn to do everything that may fit him in time for an advanced position.

GRAPHITE IN STEAM-FITTING.

Few steam-fitters or engineers understand the valuable properties of graphite in making up joints; this valuable mineral cannot be overestimated in this connection. Indestructible under all changes of temperature, a perfect lubricant and an anti-incrustator, any joint can be made up perfectly tight with it and can be taken apart years after as easy as put together. Rubber or metal gaskets, when previously smeared with it, will last almost any length of time, and will leave the surface perfectly clean and bright. Few engineers put to sea without a good supply of this valuable mineral, while it seems to be almost overlooked on shore.

HORSE POWER—NOMINAL, INDICATED AND EFFECTIVE, WITH RULES FOR DETERMINING THE HORSE POWER OF AN ENGINE.

Engineers and others who never carefully considered the matter, often use the three terms above as synonymous. While the terms are far from having a like meaning, still we often hear the nominal horse power of a steam engine spoken of when the person using the expression really means the indicated power. To show the distinctive difference between the meanings of the words nominal, indicated and effective, as applied to the term horse power, is our aim.

A horse power is merely an expression for a certain amount of work, and involves three elements—force, space and time. If the force be expressed in pounds and the space passed through in feet, then we have a solution of, and meaning for, the term foot-pound; from which it will be seen that a foot-pound is a resistance equal to one pound moved through a vertical distance of one foot. The work done in lifting thirty pounds through a height of fifty feet is fifteen hundred foot-pounds. Now, if the foot-pounds required to produce a certain amount of work involve a specified amount of time during which the work is performed, and if this number of foot-pounds is divided by the equivalent number representing one horse power (which number will depend upon the time), then the resulting number will be the horse power developed.

For example, suppose the 1,500 foot-pounds just spoken of to have acted in one second. To find the horse power divide by 550, and the result will be the horse power.

A horse power is 33,000 foot-pounds per minute; or, in other words, 33,000 pounds lifted one foot in one minute, or one pound lifted 33,000 feet in one minute, or 550 pounds lifted one foot in one second, etc.

The capacity for work of a steam engine is expressed in the number of horse powers it is capable of developing.

Nominal horse power is an expression which is gradually going out of use, and is merely a conventional mode of describing the dimensions of a steam engine for the convenience of makers and purchasers of engines. The mode of computing the so-called nominal horse power was established by the practice of some of the early English manufacturers, and is as follows:

Assume the velocity of the piston to be 128 feet per minute multiplied by the cube root of length of stroke in feet.

Assume the mean effective pressure to be seven pounds

per square inch. From these fictitious data and the area of the piston compute the horse power; that is, nominal horse power $= 7 \times 128 \times \sqrt[3]{\text{stroke in feet}} \times$ area of piston in square inches $\div 33{,}000$.

Indicated horse power is the true measure of the work done within the cylinder of a steam engine, and is based upon no assumptions, but is actually calculated. The data necessary are: The diameter of the cylinder in inches, length in feet, the mean effective pressure and number of revolutions per minute. As we have before stated, or implied, work is force acting through space, and a horse power is the amount of work in a specified time. In a steam engine the force which acts is the product of the area of the piston in square inches multiplied by the mean effective pressure; the space is twice the stroke in feet, or one complete revolution, multiplied by the number of revolutions per minute.

Therefore, indicated horse power equals the area of the piston, multiplied by the mean effective pressure, multiplied by the piston speed in feet per minute divided by 33,000.

Effective horse power is the amount of work which an engine is capable of performing, and is the difference between the indicated horse power and horse power required to drive the engine when it is running unloaded.

Engine rating, guarantees, etc., are usually based upon the indicated horse power, owing to the ease and accuracy with which it can be determined, and as a means of comparison.

Nominal horse power is computed from fictitious data.

Indicated horse power is computed from actual data, which is arrived at by means of what is known as the steam engine indicator.

Effective horse power is computed from actual data, either by means of the indicator, brake or dynamometer.

THE CARE OF MACHINERY.

The money spent in keeping machinery clean and in order is by no means wasted. The better the machinery, the greater the necessity for proper supervision. The first knock in an engine, the smallest leak in a boiler, the slightest variation from truth in a mill spindle, the wearing down of roller bearings, heating of journals, should be rectified immediately. The smooth and even working of machinery has a great deal to do with the cost of driving, while avoidance of the risk of breakage saves a large sum that would otherwise be spent in repairs.

FOAMING IN BOILERS.

The causes are dirty water; trying to evaporate more water than the size and construction of the boiler is intended for; taking the steam too low down; insufficient steam room; imperfect construction of boiler, and too small a steam pipe.

Take a kettle of dirty water and place it on a fire and allow it to boil and watch it foam, and it will be the same in a boiler.

Too little attention is paid to boilers with regard to their evaporating power. Where the boiler is large enough for the water to circulate, and there is surface enough to give off the steam, foaming never occurs. As the particles of steam have to escape to the surface of the water in the boiler, unless that is in proportion to the amount of steam to be generated, it will be delivered with such violence that the water will be mixed with it and cause what is called foaming.

A high pressure insures tranquillity at the surface, and, the steam itself being more dense, it comes away in a more compact form, and the ebullition at the surface is no greater than at a lower pressure. When a boiler foams, we close the throttle to check the flow, and that keeps up the pressure and lessens the sudden delivery.

Too many flues in a boiler obstruct the passage of the steam from the lower part of the boiler on its way to the surface; this is a fault in construction, but nearly all foaming arises from dirty water, or from trying to evaporate too much water without heating surface or steam room enough. Usually, when first put in, a boiler and engine are large enough, but, as business increases, more machinery is added until the power required is greater than can be furnished by the engine, more pressure has to be carried, and the number of revolutions increased; consequently the evaporating power of the boiler is forced beyond its ability, the steam being drawn off so rapidly that a large portion of water is drawn with it — so much that it would astonish any engineer if he had a testing apparatus attached to the steam pipe.

For the remedy of foul water there are numerous contrivances to prevent it from entering the boiler, which is a far better way than trying to extract the sediment after it is there — though there are many ingenious methods for doing that also. Faulty construction, or lack of capacity, the engineer cannot help, but he soon learns how to run the boiler to get the best possible results from it.

Every intelligent engineer has observed that his engine has an individuality not possessed by any other he ever ran, and nothing but personal acquaintance can get the best work out of it; so it is with the boiler.

The steam pipe may be carried through the flange six inches into the dome, which would prevent the water from entering the pipes by following the sides of the dome as it does.

For violent ebullition a plate hung over the hole where the steam enters the dome from the boiler is a good thing, and prevents a rush of water by breaking it when the throttle is opened suddenly.

Clean water, plenty of surface, plenty of steam room, large steam pipes, boilers large enough to generate steam without forcing the fires, are all that is required to prevent foaming. A surface blow-off is a grand thing, and helps a foaming boiler, and would be a good thing on every boiler, as you can then skim it as you would an open kettle.

HAND-HOLE PLATES.

They should be placed in such a position as to be accessible and at or near all those parts of the boiler where scale or sediment is liable to accumulate In the locomotive stationary boiler there should be one in each outside corner of the fire box and above the bottom ring, and one in each head under the tubes. In the upright tubular there should be at least two hand-hole plates above the ring, and one over the furnace door, on a line with the lower tube sheet, as in the locomotive boiler. The horizontal boiler should have one in each head under the tubes, and the rule generally observed is, that, whenever sediment is deposited, then there should be a hand-hole to get at it for a regular cleaning out.

These plates should be removed once a month, or oftener if necessary, to keep them clean, and are never considered an article of ornament, but of primary importance.

BOILING.

Let it be remembered, that the boiling spoken of so often is really caused by the formation of the steam particles, and that, without the boiling, there can be but a very slight quantity of steam produced.

While pure water boils at 212°, if it is saturated with common salt, it boils only on attaining 224°, alum boils at 220°, sal ammoniac at 236°, acetate of soda at 256°, pure nitric acid boils at 248°, and pure sulphuric acid at 620°.

INCRUSTATION OF STEAM BOILERS.

One of the greatest difficulties to be contended against in steam engineering is the incrustation on the boiler walls, arising from impure water. This crust is a poor conductor of heat, and causes increased fuel consumption, as well as the oxidizing or "burning" of the plates, owing to their increased temperature. A plate of iron 37½ inches thick conducts heat as well as a "crust" of one inch. A boiler bearing scale only 1-16 inch thick requires 15 per cent. more fuel, with ¼ inch 60 per cent. more, ½ inch 150 per cent. more. If the plates be clean, 90 pounds of steam require a plate temperature of only 325° F.; that is, about 5° above the steam temperature. But if there be a ½ inch scale or crust, the plate must be heated to about 700°, or nearly "low red" heat. Now, about 600° iron soon gets granular and brittle; hence such a scale is dangerous in its results. Crust also retards the circulation of the water. Two very common ingredients in boiler scale are carbonate of lime and sulphate of lime, or gypsum. The moderate use of soda ash (say one part in 5,000 of water) holds this deposit in check, by producing from the principal ingredients a *neutral* carbonate of lime, which will not adhere to the plates, when thus rapidly formed. Soda ash, if used in excess, boils up and passes into the cylinders and pumps, clogging up valves and pistons by combining with the lubricants. If the gauge-glasses become muddy, too much soda water is used. It is much better to supply the boilers with pure water that can deposit no scale, this being done by means of filters and heaters, or by surface-condensers, and being especially advisable with sectional and water tube boilers.

SUPERHEATED STEAM.

Superheated steam is made by drawing steam from the boiler and heating it after it has ceased to be in contact with the water in the boiler. The apparatus by which the extra heat is imparted is called a super-heater. The steam is conducted through the pipes, and hot air and gases of combustion are passed around the outside of them, thus raising the temperature and forming a more perfect gas.

STEAM GAUGES.

Steam gauges indicate the pressure of steam above the atmosphere, the total pressure being measured from a perfect vacuum, which will add 14 7-10 pounds on the average to the pressure shown on the steam gauge.

IMPORTANT TO THOSE OPERATING STEAM BOILERS.

In view of the numerous boiler explosions that have recently occurred, we submit to them the following pertinent questions asked by the *American Machinist*, which should command the careful consideration of every steam user in the land:

How long since you were inside your boiler?

Were any of the braces slack?

Were any of the pins out of the braces?

Did all the braces ring alike?

Did not some of them sound like a fiddle-string?

Did you notice any scale on flues or crown sheet?

If you did, when do you intend to remove it?

Have you noticed any evidence of bulging in the fire-box plates?

Do you know of any leaky socket bolts?

Are any of the flange joints leaking?

Will your safety valve blow off itself, or does it stick a little sometimes?

Are there any globe valves between the safety valve and the boiler? They should be taken out at once, if there are.

Are there any defective plates anywhere about your boiler?

Is the boiler so set that you can inspect every part of it when necessary?

If not, how can you tell in what condition the plates are?

Are not some of the lower courses of tubes or flues in your boiler choked with soot or ashes?

Do you absolutely know, of your own knowledge, that your boiler is in safe and economical working order, or do you merely suppose it is?

HOW TO PREVENT ACCIDENTS TO BOILERS.

1st. Carry regular steam pressure.

2d. Start the engine slowly so as not to make a violent change in the condition of the water and steam, and, when consistent, stop the engine gradually.

3d. Carry sufficient water in the boiler.

4th. Do not exceed the pressure in pounds per square inch allowed to be carried.

5th. See that every appliance of the boiler, feed pipes and safety-valve, fusible plugs, etc., are in complete working order.

PRINCIPLES ON WHICH BOILERS AND THEIR FURNACES SHOULD BE CONSTRUCTED.

Hitherto, those who have made boiler-making a separate branch of manufacture, have given too much attention to mere relative proportions. One class place reliance on enlarged grate surface, another on large absorbing surfaces, while a third demand, as the grand panacea, "boiler-room enough," without, however, explaining what that means. Among modern treatises on boilers, this principle of room enough seems to have absorbed all other considerations, and the requisites, in general terms, are thus summed up :

1. Sufficient amount of internal heating surface.
2. Sufficient roomy surface.
3. Sufficient air-space between the bars.
4. Sufficient area in the tubes or flues ; and
5. Sufficiently large fire-bar surface.

In simpler terms, these amount to the truism — give sufficient size to all the parts, and thus avoid being deficient in any.

With reference to the proportions of the several parts of a furnace, there are two points requiring attention ; first, the superficial area of the grate for retaining the solid fuel or coke ; and, second, the sectional area of the chamber above the fuel for receiving the gaseous portion of the coal.

As to the *area of the grate-bars*, seeing that it is a solid body that is to be laid on them, requiring no more space than it actually covers at a given depth, it is alone important that it be *not too large.* On the other hand, as to the *area of the chamber* above the coal, seeing that it is to be occupied by a gaseous body, requiring room for its rapidly enlarging volume, it is important that it be *not too small.*

As to the best proportion of the grate, this will be the easiest of adjustment, as a little observation will soon enable the engineer to determine the extent to which he may increase or diminish the length of the furnace. In this respect the great desideratum consists in confining that length within such limits that it shall, at all times, be well and uniformly covered. This is the absolute condition and *sine qua non* of economy and efficiency ; yet it is the very condition which, in practice, is the most neglected. Indeed, the failure and uncertainty which has attended many anxiously conducted experiments has most frequently arisen from the neglect of this one condition.

If the grate-bars be not equally and well covered, the

air will **enter in irregular and rapid** streams or masses, through the uncovered parts, and at the very time when it should be there most restricted. Such a state of things at once bids defiance to all regulation or control. Now, on the control of the supply of air depends all that human skill can do in effecting perfect combustion and economy ; and, until the supply of fuel and the quantity on the bars be regulated, it will be impossible to control the admission of the air.

Having spoken of the grate-bar surface, and what is placed on it, we have next to consider the chamber part of the furnace, and what is formed therein. In marine and cylindrical land boilers, this chamber is invariably made too shallow and too restricted.

The proportions allowed are indeed so limited as to give it rather the character of a large tube, whose only function should be, the allowing the combustible gases to pass through it, rather than that of a chamber, in which a series of consecutive chemical processes were to be conducted. Such furnaces by their diminished areas, have also this injurious tendency, — that they increase the already too great rapidity of the current through them.

The constructing the furnace chamber so shallow and with such inadequate capacity, appears to have arisen from the idea, that the nearer the body to be heated was brought to the source of heat, the greater would be the quantity received. This is no doubt true when we present a body to be heated in front of a fire. When, however, the approach of the colder body will have the direct effect of interfering with the processes of nature (as in gaseous combustion), it must manifestly be injurious. Absolute contact with flame should be avoided where the object is to obtain all the heat which would be produced by the combustion of the entire constituents of the fuel.

So much, however, has the supposed value of near approach, and even impact, prevailed, that we find the space behind the bridge, frequently made but a few inches deep, and bearing the orthodox title of the flame-bed. Sounder views have, however, shown that it should be made capacious, and the impact of the flame avoided.

As a general view, deduced from practice, it may be stated that the depth between the top of the bars and the crown of the furnace should not be less than two feet six inches where the grate is but four feet long ; increasing in the same ratio where the length is greater ; and secondly, that the depth below the bars should not be less, although depth there is not so essential either practically or chemically.

PROPERTIES OF SATURATED STEAM.

Pressure. By Steam Gauge.	Pressure. Total	Temperature in Fahrenheit Degrees	Volume. Compared with Water.	Volume. Cubic Feet of Steam from 1 lb. of Water.	Latent Heat in Fahrenheit Degrees.	Total heat required to generate 1 lb. of Steam from Water at 32 deg. under constant pressure.
						In Heat Units.
0	15	212.0	1642	26.36	965.2	1146.1
5	20	228.0	1229	19.72	952.8	1150.9
10	25	240.1	996	15.99	945.3	1154.6
15	30	250.4	838	13.46	937.9	1157.8
20	35	259.3	726	11.65	931.6	1160.5
25	40	267.3	640	10.27	926.0	1162.9
30	45	274.4	572	9.18	920.9	1165.1
35	50	281.0	518	8.31	916.3	1167.1
40	55	287.1	474	7.61	912.0	1169.0
45	60	292.7	437	7.01	908.0	1170.7
50	65	298.0	405	6.49	904.2	1172.3
55	70	302.9	378	6.07	900.8	1173.8
60	75	307.5	353	5.68	897.5	1175.2
65	80	312.0	333	5.35	894.3	1176.5
70	85	316.1	314	5.05	891.4	1177.9
75	90	320.2	298	4.79	888.5	1179.1
80	95	324.1	283	4.55	885.8	1180.3
85	100	327.9	270	4.33	883.1	1181.4
90	105	331.3	257	4.14	880.7	1182.4
95	110	334.6	247	3.97	878.3	1183.5
100	115	338.0	237	3.80	875.9	1184.5
110	125	344.2	219	3.51	871.5	1186.4
120	135	350.1	203	3.27	867.4	1188.2
130	145	355.6	190	3.06	863.5	1189.9
140	155	361.0	179	2.87	859.7	1191.5
150	165	366.0	169	2.71	856.2	1192.9
160	175	370.8	159	2.56	852.9	1194.4
170	185	375.3	151	2.43	849.6	1195.8
180	195	379.7	144	2.31	846.5	1197.2

This table gives the value of all properties of saturated steam required in calculations connected with steam boilers.

SODA ASH IN BOILERS.

An English boiler inspection company recommends that soda ash be used to prevent scale, instead of soda crystals; and that it be pumped in regularly and continuously in solution, with the feed, instead of spasmodically dumped in solid through the manhole. Tungstate of soda, instead of either soda ash or soda crystal, has been recommended strongly by some high authorities in lieu of the above.

STEAM COAL.

Steam coal, being, as everybody knows, unquestionably the most important and largest expense in the manufacture of steam, is deserving a most careful investigation by engineers and owners, who, unlike chemists and college professors, consider the subject wholly in a practical way, as relating to the coal bills of their establishments.

Useful knowledge of every-day economy of coal is seldom gained by "tests" conducted by experts, for several reasons so plain that they will not require explanation. 1st. The cost of the fuel used in tests, whatever may be stated, is too high, average or "every-day" coal not being used. The experiments are made with picked men and picked fuel, for brief periods, with everything at its best, and the results attained, if looked for in the ordinary run of business, will be disappointment in the results of the wholesale order. 2d. Men, working as firemen, twelve or fourteen hours per day in the hot furnace rooms, cannot be expected, with the ordinary appliances, to watch where every lump of coal falls when feeding the furnaces, nor to clean the grates any oftener than they are compelled to do. 3d. Moreover, too many employers favor the low wages plan, and, for the apparent saving of a few dollars per month, waste many times the amount in their furnace doors, and render their establishments most disagreeable to their neighbors, by a free distribution of unconsumed carbon, or what is commonly called *soot*, and of which most people have no appreciation. 4. Little or no encouragement is given for careful or economical firing, as a rule. The fireman who oftentimes wastes as much as his entire wages, secures the same pay as the man working alongside of him who saves it all. It may be remarked that this is "not business," but many are the concerns who run their steam plants upon this system. Careful handling of coal in firing pays better than any other thing about a steam plant, and it is the wisest economy to secure good and careful men to do it.

As is well understood, the conditions or circumstances attending the combustion of coal for steam purposes, embraces a wide range. A very few establishments work under conditions that admit of a high attainment of economy by having a fixed performance of duty, and their plants well proportioned to the regular work, but by far the largest number having a fluctuating demand for steam, and in that respect are largely at a disadvantage. Many furnaces are badly constructed, others suffer from an insufficiency of

draft, and in many cases there seems to be no end of complications detrimental to best results.

These practical difficulties and uncertainties, which are well known to every experienced engineer, render any investigation worthy of the name, slow and laborious. It has taken considerable time and research to arrive at the conclusion, though differing from the preponderance of hearsay or guess-work evidence, that now, at least, "*the highest priced coal is not the cheapest for steam production*," and that, in fact, the reverse is undoubtedly true, especially in the Western country. Late improvements in the construction of grate bars have undoubtedly added largely to the value of Western soft coals. The great difficulty, in former times, of ridding the furnaces of the incombustible part of these very valuable coals, has now been removed by improvements, and there is no doubt but what a large number of extensive establishments in the West are now, and for some time past have been, obtaining the same duty from the Illinois bituminous coals that they in former years obtained from the high-priced Eastern coals.

BLOWING OFF UNDER PRESSURE.

A boiler can be seriously impaired by blowing it down under a high pressure, and with hot brick work. The heat from the latter will granulate the iron and reduce its tensile strength. A boiler should not be blown right down under a higher pressure than twenty pounds, and not less than four hours after the fire has been drawn.

When a boiler is exposed to cold air, especially in the winter, it is advisable that the damper be closed and the doors thrown open, or *vice-versa*. If both are left open, the strong draught of cold air will cool off the flues faster than the shell; which abuse, if kept up, would reduce the length of the life of the boiler.

THE TOTAL PRESSURE.

A boiler eighteen feet in length by five feet in diameter, with forty-four inch tubes, under a head of eighty pounds of steam, has a pressure of nearly 113 tons on each head, 1,625 tons on the shell and 4,333 tons on the tubes, making a total of 6,184 tons on the whole of the exposed surfaces.

This calculation is made by finding the total square inches under pressure, and multiplying the totals by the pressure, in this case, 80 pounds to the square inch.

Table Showing Safe Working Steam Pressure for Iron Boilers of different sizes, using a Factor of Safety of Six.

Internal Diameter of Shell in inches.	Thickness of Iron.	Longitudinal Seams, Single Riveted. Tensil Strength of Iron.			Longitudinal Seams, Double Riveted. Tensil Strength of Iron.		
		45,000 Lbs. Pressure.	50,000 Lbs. Pressure.	55,000 Lbs. Pressure	45,000 Lbs. Pressure.	50,000 Lbs. Pressure.	55,000 Lbs. Pressure.
	INCH.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
36	$\frac{1}{4}$	104	116	127	125	139	152
	$\frac{5}{16}$	130	145	159	156	174	191
38	$\frac{1}{4}$	99	110	121	119	132	145
	$\frac{5}{16}$	123	137	151	148	164	181
40	$\frac{1}{4}$	94	104	115	113	125	138
	$\frac{5}{16}$	117	130	143	140	156	172
42	$\frac{1}{4}$	89	99	109	107	119	131
	$\frac{5}{16}$	112	124	136	134	149	163
44	$\frac{1}{4}$	85	95	104	102	114	125
	$\frac{5}{16}$	107	118	130	128	142	156
46	$\frac{1}{4}$	82	91	100	98	109	120
	$\frac{5}{16}$	102	113	125	122	136	150
48	$\frac{1}{4}$	78	87	96	94	104	115
	$\frac{5}{16}$	98	109	120	118	131	144
	$\frac{3}{8}$	118	131	144	142	157	173
50	$\frac{1}{4}$	75	83	92	90	100	110
	$\frac{5}{16}$	94	104	115	113	125	138
	$\frac{3}{8}$	112	125	138	134	150	166
52	$\frac{1}{4}$	72	80	88	86	96	106
	$\frac{5}{16}$	90	100	110	108	120	132
	$\frac{3}{8}$	108	120	132	130	144	158
54	$\frac{5}{16}$	87	96	106	101	112	122
	$\frac{3}{8}$	104	116	127	120	134	148
	$\frac{7}{16}$	121	135	148	140	156	172
60	$\frac{5}{16}$	78	87	95	94	104	114
	$\frac{3}{8}$	94	104	115	113	125	138
	$\frac{7}{16}$	109	121	134	131	145	160
66	$\frac{3}{8}$	85	95	104	102	114	125
	$\frac{7}{16}$	99	111	121	120	133	146
	$\frac{1}{2}$	112	117	138	137	152	167
72	$\frac{3}{8}$	78	87	96	94	104	115
	$\frac{7}{16}$	91	102	112	110	122	134
	$\frac{1}{2}$	102	117	128	125	140	153

STEAM HEATING.

The advantages of steam heating are set forth by Prof. W. P. Trowbridge, in the *North American Review*, as follows:

1. The almost absolute freedom from risk of fire when the boiler is outside of the walls of the building to be heated, and the comparative immunity under all circumstances.

2. When the mode of heating is the indirect system, with box coils and heaters in the basement, a most thorough ventilation may be secured, and it is in fact concomitant with the heating.

3. Whatever may be the distance of the rooms from the source of heat, a simple steam pipe of small diameter conveys the heat. From the indirect heaters underneath the apartments to be heated, a vertical flue to each apartment places the flow of the low heated currents of the air under the absolute control of the occupants of the apartment. Uniformity of temperature, with certainty of control, may be thus secured.

4. Proper hygrometric conditions of the air are better attained. As the system supplies large volumes of air heated only slightly above the external temperature, there is but little change in the relative degree of moisture of the air as it passes through the apparatus.

5. No injurious gases can pass from the furnace into the air flues.

6. When the method of heat is by direct radiation in the rooms, the advantage of steadiness and control of temperature, sufficient moisture and good ventilation, are not always secured; but this is rather the fault of design, since all these requirements are quite within reach of ordinary contrivances.

7. One of the conspicuous advantages of steam heating is that the most extensive buildings, whole blocks, and even large districts of a city may be heated from one source, the steam at the same time furnishing power where needed for ventilation or other purposes, and being immediately available also for extinguishing fires, either directly or through force pumps.

STOPPING WITH A HEAVY FIRE.

When it becomes necessary to stop an engine with a heavy fire in the furnace, place a layer of fresh coal on the fire, shut the damper and start the injector or pump for the purpose of keeping up the circulation in the boiler.

ANALYSIS OF BOILER INCRUSTATION.

BY DR. WALLACE.

Carbonate of lime	64.98
Sulphate of lime	9.33
Magnesia	6.93
Combined water	3.15
Chloride of sodium	.23
Oxide of iron	1.36
Phosphate of lime of alumina	3.72
Silica	6.60
Organic matter	1.60
Moisture at 212 degrees F.	2.10
	100.

CLEANING BOILER TUBES.

The method of cleaning boiler tubes depends upon the kind of fuel used. A steam jet will not answer where wood and soft coal are used, but will do for hard coal, though in any case a scraper is indispensable, where a steam jet is not. Soot and dust will collect in the tubes and burn on so as to require more than a jet of steam to move it. A steam jet or blower should be used only where dry steam is at hand, but by no means with wet steam. Before using the jet, thoroughly blow all the water out of it and heat it up. We have seen some men put the point of the jet in a tube and turn on steam before warming, and then wonder what caused the brick work to crumble away at the back end.

CLEANING BRASS.

The government method prescribed for cleaning brass, and in use at all the United States arsenals, is said to be the best in the world. The plan is, to make a mixture of one part of common nitric, and one-half part sulphuric acid in a stone jar, having also a pail of fresh water and a box of saw-dust. The articles to be treated are first dipped into the acid, then removed into the water, and finally rubbed with the saw-dust. This immediately changes them into a brilliant color. If the brass has become greasy, it is first dipped into a strong solution of potash or soda, in warm water. This dissolves the grease, so that the acid has power to act.

THE THERMAL UNIT

Is the heat necessary to raise one pound of water at 39° F. one degree, or to 40° F.

SMOKE — HOW FORMED.

When fresh coal is placed on a fire in an open grate, smoke arises immediately; and the cause of this smoke is not far to seek, as it will be easily understood that, before fresh coals were put upon the fire within the grate, the glowing coals radiated their heat and warmed the air above, and thereby enabled the rising gases to at once combine with the warmed air to produce combustion; but, when the fresh coals are placed upon the fire, they absorb the heat, and the air above remains cold.

By gases, is meant the gases arising from coals while on or near the fire, and it may not be known to every one that we do not burn coals, oils, tallow or wood, but only the gases arising from them. This can be made clear by the lighting of a candle, which will afford the information required. By lighting the candle, fire is set to the wick, which, by its warmth, melts a small quantity of tallow directly absorbed by the capillary tubes of the wick, and thereby so very finely and thinly distributed that the burning wick has heat enough to be absorbed by the small quantity of dissolved tallow to form the same into gases, and these gases burning, combined with the oxygen in the atmosphere, give the light of the candle. A similar process is going on in all other materials; but coal contains already about seventeen per cent. of gases, which liberate themselves as soon as they get a little warm. The smaller the coal, the more rapidly will the gases be liberated, so that, in many cases, only part of the gases are consumed.

The fact is, that the volatile gases from the coal cannot combine with cold air for combustion. Still combustion takes place in the following ways. The cold air, in the act of combination, absorbs a part of the warmth of the rising gases, which they cannot spare, and, therefore, must condense, so that small particles are formed, which aggregate and are called smoke, and when collected, produce soot; but as long as these particles and gases are floating, they cannot burn or produce combustion, as they are surrounded by a thin film of carbolic acid. It is only when collected and this acid driven off, that they are consumed.

It has now been shown that cold is the cause of smoke, which may be greatly reduced by care. In the open fire grate the existing fire ought to be drawn to the front of the grate, and the fresh coal placed behind, or in the back of the fire. The fire in the front will then burn more rapidly, warm the air above, and prepare the raising gases for com-

bustion. In this way smoke is diminished, as the gases from the coals at the back rise much more slowly then when placed upon the fire and the air partly warmed.

WHAT IS LATENT HEAT?

Heat has its equivalent in mechanical work, and, when heat disappears, work of some kind will take its place. When a body changes from the liquid to the gaseous form, the molecules have to be separated and placed in different positions with regard to each other. This calls for an expenditure of work. This work is supplied by heat, which disappears at the time. One can hold his hand in steam escaping from a safety valve of a boiler for this reason. The heat of the steam disappears in pushing apart and rearranging the molecules of the steam as it expands when it leaves the safety valve.

The term latent heat, as commonly used, means the amount of heat which disappears when water changes from a liquid into steam. This is considerable, as will be seen by consulting any table of the heat contained in steam, and the water from which it comes.

Water at 212° contains 180 units of heat. Steam at 212° contains 1,146 units of heat. The latent heat is the difference of 966 units. Such a large quantity disappears when liquid water changes to steam, that boiling cannot be raised above 212°, no matter how hard it is boiled. The heat becomes latent, and the mechanical work, or rather molecular work, is sufficient to take up all that is supplied by the fire.

The specific heat of air at constant pressure being 0.2377, the specific heat of water, which is 1, is, therefore, 4.1733 times greater under ordinary circumstances. A pound of water losing 1° of heat, or one thermal unit, will consequently raise the temperature of 4.17 pounds, or, at ordinary temperatures, say 50′ of air, 1°. A pound of steam at atmospheric pressure, having a temperature of 212° F., in condensing to water at 212° F., yields 966 thermal units, which, if utilized, would raise the temperature of $5 \times 966 =$ 4830′ of air 1°, or about 690′ from 5° to 70° F.

MISTAKES IN DESIGNING BOILERS.

One of the greatest mistakes that can be made in designing boilers, and the one that is most frequently made of any, consists in putting in a grate too large for the heating surface of the boiler, so that with a proper rate of combustion of the fuel an undue proportion of the heat developed passes off through the chimney, the heating surface of the boiler being insufficient to permit its transmission to the water. This mistake has been so long and so universally made, and boiler owners have so often had to run slow fires under their boilers to save themselves from bankruptcy, that it has given rise to the saying, "Slow combustion is necessary for economy." This saying is considered an axiom, and regarded with great veneration by many, when the fact is, if the truth must be told, it has been brought about by the wastefulness entailed by boiler plants and proportioned badly by ignorant boilermakers and ignorant engineers, who ought to know better, but don't.

Let us consider the matter briefly: Suppose we are running the boiler at a pressure of 80 ℔s. per square inch, the temperature of the steam and water inside will be about 325 degrees F.; the temperature of the fire in the furnace will, under ordinary conditions, be about 2,500 degrees F. Now, it should be clear to the dullest comprehension, that we can transmit to the water in the boiler only that heat due to the difference between the temperature in the furnace and that in the boiler. In case of the above figures, about seven-eighths of the total heat of combustion is all that could, by any possibility, be utilized, and this would require that radiation of heat from every source should be absolutely prevented, and that the gases should leave the boiler at the exact temperature of the steam inside, or 325 degrees.

To express the matter plainly, we may say that the utilization of the effect of a *fall* of temperature of 2.175 degrees is all that is possible.

Now, suppose, as one will actually find to be the case in many cases if he investigates carefully, that the gases leave the flues of another steam boiler at a temperature between 500 and 600 degrees. The latter temperature will be found quite common, as it is considered to give "good draft." This is quite true, especially as far as the "draft" on the owner's pocket-book is concerned, for he cannot possibly utilize under these conditions more than 2,500—500=2,000 degrees of that inevitable difference of temperature to which he is confined, or four-fifths of the total, instead of the

seven-eighths, as shown above, where the boiler was running just right, and any attempt to reduce the temperature of the escaping gases by means of slower "combustion," as he would probably be advised to do by nine out of ten men, would simply reduce the temperature of the fire in his furnace, and the economical result would be about the same. His grate is too large to burn coal to the best possible advantage, and his best remedy is to reduce its size and keep his fire as hot as he can.

This is not speculation, as some may be inclined to think. Direct experiments have been made to settle the question. The grate under a certain boiler was tried at different sizes with the following result:

With grate six feet long ratio of grate to heating surface was 1 to 24.4.

With grate four feet long ratio of grate to heating surface was 0 to 36.6.

The use of the smaller grate gave, with different fuels and all the methods of firing, an average economy of nine per cent. above the larger one, and, when compared by burning the same amount of coal per hour on each, twelve per cent. greater rapidity of evaporation and economy were obtained with the smaller grate.

AVERAGE BREAKING AND CRUSHING STRAINS OF IRON AND STEEL.

Breaking strain of wrought iron =23 tons	Per square inch of section.
Crushing strain of wrought iron =17 tons	
Breaking strain of cast iron about 7½ tons	
Crushing strain of cast iron =50 tons....	
Breaking strain of steel bars about 50 tons	
Crushing strain of steel bars up to 116 tons	

PITTING OF MUD DRUMS.

Mud drums have frequently been known to pit through their close connection to the brick work with which they are covered. When the boiler is filled with cold water, the iron will sweat. This moisture mixing with the lime of the brick work will, after a length of time, injure the iron. Mud drums are injured on the inside by a similar chemical action. The sediments of lime, etc., deposit there where their action goes on undisturbed by any circulation. To prevent pitting on the inside from this cause, blow down frequently, and, on the outside, keep the brick off the plates, so that all moisture can pass off.

TABLE OF SPECIFIC GRAVITIES.

	Weight of a Cubic Inch in Lbs.
Copper, cast	.3178
Iron, cast	.263
Iron, wrought	.276
Lead	.4103
Steel	.2827
Sun-metal	.3177

DIVISIONS OF DEGREES OF HEAT.

The thermometer is an instrument for measuring sensible heat. It consists of a glass tube of very fine bore, terminating in a bulb. This bulb is filled with mercury, and the top of the tube is hermetically sealed after all the air has been expelled. The instrument is then put into steam arising from boiling water, and, when the barometer stands at thirty inches, a mark is placed on a scale affixed opposite the place the mercury stands at. It is again put in melting ice, and the scale again marked. The space between these marks is divided into spaces called degrees. In this country and England it is divided into 180 equal parts, calling freezing point 32°, so that the boiling point is 212°; and zero or 0 is 32° below freezing point, and this scale is called Fahrenheit's. On the continent two other scales are in use; the Centigrade, in which the space is divided into 100 equal parts, hence the name; and Reaumur's, in which the space is divided into 80. In both of these scales freezing point is 0, or zero; so that the boiling point of centigrade is 100°, and Reaumur 80°.

THE LAW OF PROPORTION IN STEAM ECONOMY.

The basis of steam engineering science consists in closely adhering to the absolute ratio or proportion of the different parts of the steam-plant, representing the power of the engine and boiler to the amount of the work to be done. To use an extreme illustration, it is not scientific to construct a hundred horse power boiler — say 1,500 square feet of heating surface — to furnish steam for a six-inch cylinder; nor is it in proportion to use a cylinder of the latter size to drive a sewing machine. It may be said truthfully that the law of true proportion between boiler, engine and the desired amount of work is less understood than almost any other in the range of mechanical practice.

VALUABLE INFORMATION FOR ENGINEERS.

To find the capacity of a cylinder in gallons, multiply the area in inches by the length of stroke in inches, and it will give the total number of cubic inches; divide this by 231, and you will have the capacity in gallons.

The U. S. standard gallon measures 231 cubic inches, and contains 8⅓ pounds of distilled water.

The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch.

The average amount of coal used for steam boilers is 12 pounds per hour for each square foot of grate.

The average weight of anthracite coal is 53 pounds to one cubic foot of coal; bituminous, about 48 pounds to the cubic foot.

Locomotives average a consumption of 3,000 gallons of water per 100 miles run.

To determine the circumference of a circle, multiply the diameter by 3.1416.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434, approximately, every foot elevation is equal to ½ pound pressure per square inch, allowing for ordinary friction.

The area of the steam piston, multiplied by the steam pressure, gives the total amount of pressure that can be exerted. The area of the water piston, multiplied by the pressure of water per square inch gives the resistance. A margin must be made between the power and the resistance to move the pistons at the required speed, from 20 to 40 per cent., according to speed and other conditions.

To determine the diameter of a circle, multiply circumference by .31831.

Steam at atmospheric pressure flows into a vacuum at the rate of about 1550 feet per second, and into the atmosphere at the rate of 650 feet per second.

To determine the area of a circle, multiply the square of diameter by .7854.

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into one cubic foot of steam (approximately).

By doubling the diameter of a pipe, you will increase its capacity four times.

In calculating horse-power of tubular or flue boilers, consider 15 square feet of heating surface equivalent to one nominal horse-power.

HOW TO TEST BOILERS.

The safe-working pressure of any boiler is found by multiplying twice the thickness of plate by its tensile strength in pounds, then divide by diameter of boiler, then this result divide by six. This gives safe working pressure.

EXAMPLE.

Twice thickness plate × tensile strength ÷ diameter of boiler in inches ÷ 6 = safe working pressure + one-half more = maximum test pressure.

Diameter of boiler, 60″. Thickness of plate, ½″. Tensile strength of plate, 60,000 lbs. 1″ × 60,000 ÷ 60 = 1,000 ÷ 6 = 166⅔ lbs., which is the safe working pressure + 83⅓ lbs. = 250 lbs., which is the maximum test pressure.

After the safe pressure has been found as above, the usual way is to add one-half more for a test pressure, then apply by hydraulic pressure as high as the test pressure, and, if the boiler goes through this test all right, it is safe to run it at two-thirds of test pressure.

Before putting hydraulic pressure on an old boiler, empty the boiler, go over it carefully with the hammer for broken braces, weak and corroded spots, figure for safe pressure on the thinnest place found in boiler, fill boiler full of cold water, and gradually heat it until the desired pressure is reached. By this mode of testing by hot water pressure, the heated water is expanded, and is more elastic than when cold, and is not so liable to strain the boiler.

Before allowing the pressure to be applied, see that the boiler is properly braced and stayed, and that the rivets are of proper size.

All flat surfaces, such as found in fire-box boilers, should have stays not over 5 or 6 inches apart, for all ordinary pressure and boiler heads not over 7 inches apart.

On account of the loss of strength in the plates by rivet holes, some authorities allow only 70 per cent. of the safe pressure given above, for double-riveted boilers, and 56 per cent. for single-riveted boilers:

EXAMPLE.

166 lbs. safe pressure in first example × 70 per cent. for double-rivets = 116.20 lbs. safe pressure for double-riveted boiler.

166 lbs. safe pressure in first example × 56 per cent. for single-riveted seams = 92.96 lbs. safe pressure for single-riveted boilers.

SCALE IN BOILERS

Mr. T. T. Parker writes as follows to the *American Machinist:*

If there is one thing more than another that the average engineer is careful with, it is the use of boiler compounds. With an open exhaust heater and an overworked boiler, and using water from a drilled well sixty feet deep in limestone, I have had to be rather careful to avoid scale and foaming.

I offer some notes from my experience under the above conditions.

In using compounds containing sal soda, I had to use 40 per cent. more cylinder oil, and this invariably reacted, through the heater and feed water, on the boiler, and produced foaming. I have used six compounds warranted to cure foaming with above results. The compounds were tannic acid and soda.

Changing to the use of crude oil, I found that the volatile parts went over to the engine, and saved 10 per cent. cylinder oil over when using nothing, and 50 per cent. over the use of sal soda. There is a peculiar easy manner of making steam that is very different from the same boiler using sal soda. The results on scale are as follows:

In changing to a different solvent, the results for a few runs were very good, and then it seemed to lose its virtue while losing double quantity; result, foaming. With crude oil used continually, I have had scale from one-eighth inch thick, but never any thicker, as it came off clean, and was very porous. I prefer oil to any acid or alkali solvent. For cleaning a scaled boiler I would recommend alternate use of oil and sal soda, but the remedy is heroic. If the boiler is not clean in two weeks, I miss my guess. I have tried kerosene, and found it too volatile to be of value in a limestone district. In summing up the results, I believe:

First — With an open exhaust heater, use only the best cylinder oil, which should be at least 80 per cent. petroleum.

Second — If the crude oil does not keep the scale all out, alternate one run with sal soda.

Now, I only offer this as my experience, knowing full well that the conditions are never absolutely the same. But I know of a plant (in this city) where the boiler is not worked up to its full capacity, and which is kept entirely free from scale, using hard water, by the alternate use of sal soda and crude oil.

WAGES IN TWO COUNTRIES.

The poverty and low state of social civilization of the Spaniards is indexed quite accurately by their wage rates.

For instance, the average weekly pay of a bricklayer in Spain (Malaga) is $3.80; in the United States $21.18; of a mason, $3.30 in Spain, $21.00 in the United States; of a carpenter, $3.90 in Spain; $15.25 in the United States; of a blacksmith, $3.90 in Spain; $16.02 in the United States; of a tinsmith, $3 in Spain, $14.35 in the United States; of printers, $4.50 in Spain, $16.42 in the United States; of laborers, porters, etc., $2.75 in Spain; $8.88 in the United States. While rents and possibly a few native products are lower in Spain than in the United States, the difference comes nowhere equaling the wide disparity in wages. Moreover in a comparison of this sort the quality of the living must be considered as well as the nominal cost. Thus lower rents nearly always imply inferior accommodations, and, to the average Spaniard, most of the comforts and conveniences in ordinary use here are unattainable luxuries.

That the low rate of Spanish wages does really mean a proportionately low consumption and standard of living, is substantiated by one or two significant facts of another character; for instance, the per capita annual consumption of woolen goods in Spain is only 9 shillings' worth, as against 18 shillings in the United States; of sugar, 5 pounds per annum in Spain, 43 pounds in the United States; of beef, 16 pounds per annum in Spain; 62 pounds in the United States; of all meats, 49 pounds in Spain; 120 pounds in the United States; of butter, none in Spain; 16 pounds in the United States; of coffee, 4 pounds in Spain; 115 pounds in the United States.

A NOVEL DYNAMO.

At the central station of Puteaux, Paris, a novel form of dynamo was installed in 1898, which combines the efficiency of a low-speed engine and the high-tension alternating-current dynamo. The engine and dynamo are built together. the latter comprising an integral part of the engine, as the flywheel is used to carry the field magnets of the dynamo. The engine is of the high-speed Corliss type, revolving at a speed of 60-120 revolutions per minute.

The armature is fixed, but may be slid out of the magnetic field by a lateral movement. It remains motionlesss between two sets of magnetic poles and is supported by a pillar of cast iron, through which the crank shaft passes. The exciting current can be obtained either from a small auxiliary dynamo or from a shunt circuit taken from the main leads. The current is subsequently reduced by a transformer and supplied at a pressure of 200 volts; the entire operation showing a high degree of efficiency.

THE LARGEST ARMATURE.

The largest armature for the largest generator of electricity ever made in the world for a trolley railroad was completed in Cleveland, Ohio, in January, 1898, and was shipped from the works of the Walker Company for Brooklyn, N. Y. The whole generator, when assembled, is 20 feet high, 20 feet long and 15 feet wide, or equal in height to four ordinary-sized men. It is for the Brooklyn Heights Railway Company. The armature, which is the revolving part of the generator between the magnets, weighs 90,000 pounds. It is 7½ feet wide and 10½ feet high.

WEIGHT OF 1 CUBIC IN. OF VARIOUS METALS.

	Weight in lbs.	Weight in ounces.
Steel, . . .	0.2833	4.533
Cast iron, . . .	0.263	4.208
Wrought iron, . .	0.2777	4.444
Copper. . . .	0.3225	5.159
Brass, . . .	0.308	5.333

WEIGHT OF FUELS.

Coke.—4 bushels = 1 sack.	Coal.—A bushel = 74⅔ lbs.
Petroleum.—1 ton=275 galls.	A sack = 224 "

AVERAGE WEIGHT OF ANIMALS.

Cart-horse, 14 cwt.	Riding-horse, 11 cwt.
Ox, 7 to 8 "	Pig, 1 to 1½ "
Cow, 6½ to 8 "	Sheep, 1 "

Average weight of a man, 140 lbs.

A dense crowd of people, 85 lbs. per square foot.

PROPORTIONS OF STEAM BOILERS.

In a recent communication to the *Societe Scientifique Industrielle* of Marseilles, M. D. Stapfer remarked that, as he had never met with any good practical rules for the proportions of boilers for steam engines, he had taken the trouble to examine a very large number of different types, which were working satisfactorily, and from them had deduced the following rules: The water level in the boilers of torpedo boats was usually placed at two-thirds the diameter of the shell, and in marine, portable and locomotive boilers at three-fourths this diameter. The surface from which evaporation took place should, however, be made greater as the steam pressure was reduced — that was to say, as the size of the bubbles of steam became greater. To produce 100 lbs. of steam per hour, at atmospheric pressure, this surface should not be less than 7.32 square ft., which may be reduced to 1.46 square ft. for steam at 75 lbs. pressure, and 0.73 ft. for steam at a pressure of 150 lbs. It is for this reason that triple-expansion engines can be worked with smaller boilers than were required with engines using steam of lower pressure. The amount of steam space to be permitted depends upon the volume of the cylinder and the number of revolutions made per minute. For ordinary engines it may be made a hundred times as great as the average volume of steam generated per second. The section through the tubes may be one-sixth of the fire-grate area when the draught is due to chimney from 27 ft. to 33 ft. high, which in general corresponds to a fuel consumption of 12.3 pounds of coal per square foot of grate surface per hour. This area may be reduced to one-tenth that of the grate when forced draught is employed.

TESTING BOILER PLATES.

A good every-day shop plan of testing boiler plates is to cut off a strip 1¼ inches wide and of any convenient length. Drill a quarter-inch hole, and enlarge it to three-quarters of an inch by means of a drift-pin and hammer. If the plate shows no signs of fracture, it may be considered of good quality.

Another method is to cut off a narrow strip, heat it to a cherry red and cool suddenly. Grip the piece in a vise, and bend it back and forth at right angles by means of a piece of gas pipe dropped over the end. The number of times the piece can stand this bending is the measure of its quality. A good piece of soft steel boiler-plate should stand twelve or fifteen bendings without showing fracture.

MANIPULATION OF NEW ENGINES.

After engines have been set up, they must be adjusted to their work. It is not every man that can do this properly, for it requires experience and consideration to determine exactly what is to be done. A new engine is a raw machine, so to speak, and, no matter how carefully the work has been done upon it, it is not in the same condition that it will be in a few weeks, or after the actual work it does has worn its bearings smooth and true. In the best machine-work, there are more or less asperities of surface, and very much more friction than than there will be later on. Bearings and boxes are not fitted under strain; they are fitted as they stand, independently in the shop, and this entails a condition of things which actual work may show to be faulty. For this reason an engineer should not go at a new engine hammer and tongs, and try to suppress at once every slight noise or click that he may hear. Neither should he key up solid, or screw down hard, the working shafts and bearings, for the first few days. It is much better to let the things run easily for a while, at the expense of a little noise, rather than to risk cutting before the details get used to each other. Many good engines have been disabled by too great zeal on the part of those in charge, when a little forbearance would have been much better. Pounding, caused by bad adjustment, or valve setting, and pounding caused by new bearings not in intimate relation with each other, are quite different in character, and a careful engineer will not make haste to decide upon the remedy until he has indicated and investigated the engine, and found out exactly where the trouble is. Not long ago we saw a new engine badly cut in its guides from this very cause; a slight jar was noticed, and the engineer, arguing that the crosshead was the seat of the noise, set out the gibs so much that they seized and plowed some bad scores in the cast-iron guides, which will always remain to remind him of his thoughtlessness. What has been said above of the engine, is also true of the boiler and its appurtenances. No new boiler should have pressure put upon it at once. Instead, it should be heated up slowly for the first day, and whether steam is wanted or not. Long before all the joints are made, or the engine ready for steam, the boiler should be set, and in working order. A slight fire should be made and the water warmed up to about blood heat only, and left to stand in that condition and cool off, and absolute pressure should proceed by very slow stages. Persons who set a boiler and then build a roaring fire under

it, and get steam as soon as they can, need not be surprised to find a great many leaks developed ; even if the boiler does not actually and visibly leak, an enormous strain is needlessly put upon it which cannot fail to injure it. Of all the forces engineers deal with, there are none more tremendous than expansion and contraction.

STATISTICS OF MANUFACTURES IN THE UNITED STATES.

According to the United States census, the number of persons engaged in manufactures in the United States in the census year was 4,712.622, and earned wages were $2,283,-216,529.

The value of products, including receipts from custom work and repairing, was $9.372,437,283; number of establishments reporting, 322,638; capital, 6,139,397,785; cost of materials used, $5,021,453,326.

The value of the products of woolen mills in 1890 was $133,577,977; worsted mills, $79,194,652; carpet mills, $47,770,193; hosiery and knitting mills, $67,241,013; cotton mills, $267,981,724; lumber and timber products, $465,-934,244; silk mills, $87,298,454; chemicals, $177,811,833.

No general statistics of manufactures had been collected since the 1890 census. The manufacturing industries of the United States are covered by the census of 1900.

STEAM AS A CLEANSING AGENT.

For cleaning greasy machinery nothing can be found that is more useful than steam. A steam hose attached to the boiler can be made to do better work in a few minutes than any one is able to do in hours of close application. The principal advantages of steam are, that it will penetrate where an instrument will not enter, and where anything else would be ineffectual to accomplish the desired result. Journal boxes with oil cellars will get filthy in time, and are difficult to clean in the ordinary way; but, if they can be removed, or are in a favorable place, so that steam can be used, it is a veritable play work to rid them of any adhering substance. What is especially satisfactory in the use of steam, is that it does not add to the filth. Water and oil spread the foul matter, and thus make an additional amount of work.

POINTS FOR ENGINEERS.

When using a jet condenser, let the engine make three or four revolutions before opening the injection valve, and then open it gradually, letting the engine make several more revolutions before it is opened to the full amount required.

Open the main stop valve before you start the fires under the boilers.

When starting fires, don't forget to close the gauge-cocks and safety-valve as soon as steam begins to form.

An old Turkish towel, cut in two lengthwise, is better than cotton waste for cleaning brass work.

Always connect your steam valves in such a manner that the valve closes against the constant steam pressure.

Turpentine, well mixed with black varnish, makes a good coating for iron smoke pipes.

Ordinary lubricating oils are not suitable for use in preventing rust.

You can make a hole through glass by covering it with a thin coating of wax — by warming the glass and spreading the wax on it, scrape off the wax where you want the hole, and drop a little fluoric acid on the spot with a wire. The acid will cut a hole through the glass, and you can shape the hole with a copper wire covered with oil and rotten-stone.

A mixture of one (1) ounce of sulphate of copper, one-quarter (¼) of an ounce of alum, half (½) a teaspoonful of powdered salt, one (1) gill of vinegar and twenty (20) drops of nitric acid will make a hole in steel that is too hard to cut or file easily. Also, if applied to steel and washed off quickly, it will give the metal a beautiful frosted appearance.

It is a fact that thirty-five cubic feet of sea water is equal in weight to thirty-six feet of fresh water, the weight being one ton (2,240 pounds).

Remember that coal loses from ten (10) to forty (40) per-centum of its evaporative power if exposed to the influence of sunshine and rain.

Those who have had experience think that for lubricating purposes palm nut oil cannot be surpassed, for the reason that it does not gum or waste; neither does friction remove it readily from the surfaces where it is applied, and its use is exceedingly economical. The best cylinder oils produce no better effect.

If you are obliged to make use of such a barbarism as a rust joint, mix ten (10) parts by weight of iron filings, and

three (3) parts of chloride of lime with enough water to make a paste. Put the mixture between the pieces to be joined, and bolt firmly together.

Too much bearing surface in a journal is sometimes worse than too little.

Steel hardened in water loses its strength—but hardening in oil increases its strength and adds to its toughness.

PRODUCTION OF COPPER, TIN AND ZINC.

The production of copper in the world in 1898, stated in long tons, was as follows: United States, 239,241; Spain and Portugal, 53,225; Chile, 24,850; Japan, 25,175; Germany, 20,085; Mexico, 15,668; Australasia, 18,000; South Africa, 7,060; other countries, 31,025; total, 434,329 tons.

The copper production of the United States in 1898, in pounds, was distributed as follows: Arizona, 110,823,334; California, 21,543,229; Colorado, 10,870,869; Michigan, 156.669,098; Montana, 216,979,334; Utah, 5,385,246; Eastern and Southern States, 4.478,218; all others, 2,134, 999; copper in sulphate (*b*), 7,015,375; total, 535,900,232.

The production of tin in the world in 1898, in long tons, was as follows: England, 5,200; Straits Settlements, 45,901; Australasia, 3,220; Banka, Billiton, and Singkep, 14,380; Bolivia, 4.464; Austria (*e*), 49; Germany (*e*), 635; Japan (*e*), 39; Mexico (*e*), 5; Portugal, 70; Russia (*e*), 5; total, 73,268.

The production of zinc in the world in 1898, in metric tons, was as follows: Austria, 7,229; Belgium, Holland and the Rhine district of Germany, 191,836; Upper Silesia, 99,232; France and Spain, 32,649; England, 27,625; Russia, 5,664; United States, 103,514; total, 467,749.

AREA OF THE WORLD'S COAL-FIELDS, IN SQUARE MILES.

China and Japan, 200,000; United States, 194,000; India, 35,000; Russia, 27,000; Great Britain, 9,000; Germany, 3,600; France, 1,800; Belgium, Spain and other countries, 1,400. Total, 471,800.

The coal-fields of China, Japan, Great Britain, Germany, Russia and India contain apparently 303,000,000,000 tons, which is enough for 700 years at present rate of consumption.

(*b*) Including only the copper in sulphate obtained as a by-product.
(*e*) Estimated.

MEASURES OF DIFFERENT COUNTRIES

	SURFACE MEASURE.	DRY MEASURE.	LIQUID MEASURE.
Austria.. Belgium. France.. Germany Greece.. Holland. Italy..... Norway. Portugal Spain... Sweden.. Switzerland Turkey.. (METRIC SYSTEM)	1 are=100 square meters. =119.6 sq. yds. 1 hectare=10,000 sq. meters. =2.47 acres.	1 hectoliter=one-tenth cubic meter =2.8377 bu. or=3.53 cubic ft.	1 liter=1,000 cubic centimeters. =0.264 gallons.
Denmark	1 tonne=1.36 acres.	1 scheffel=0.4935 bushels.	1 pott=0.255 gallons.
England.	1 square mile=640 acres.	1 quarter=8 bushels.	1 gallon=4 qts @ 2 pts. @ 4 gills.
Russia..	1 dessätine=2.7 acres.	1 tschetwert=5.9570 bushels.	1 wedro@ 10 kruschka=3¼ gal
United States	1 sq. mile=640 acres; 1 acre=43.560 sq. feet; 1 sq. mile=259 hectares; 1 acre=0.4047 hectare.	1 bushel=4 pecks; 1 peck=8 qts.; 1 qt.=2 pts.; 1 bu.=35.24 liters. 1 cubic foot=1,728 cubic in. 1 cu. foot=0.2832 hectoliter.	1 hogshead=63 gals.: 1 gal.=4 qts.; 1 qt.=2 pts.; 1 pt.=4 gills; 1 brl.=4 firkins; 1 firkin=9 gals.; 1 gallon=3.7855 liters.

THE MONETARY UNITS AND STANDARD COINS OF FOREIGN COUNTRIES.

The first section of the act of March 3, 1873, provides "that the value of foreign coin, as expressed in the money of account of the United States, shall be that of the pure metal of such coin of standard value," and that "the value of the standard coins in circulation of the various nations of the world, shall be estimated annually by the director of the mint, and be proclaimed on the first day of January by the secretary of the treasury.

The estimates of values contained in the following table are those made by the director of the mint, Jan. 1, 1878.

Country.	Monetary Unit.	Standard.	Value. D.	C.	M.
Argen Repub...	Peso fuerte....	Gold	1	0	0
Austria	Florin	Silver.......	0	45	3
Belgium	Franc	Gold & Silver	0	19	3
Bolivia	Dollar........	Gold & Silver	0	96	5
Brazil	Milreis of 1000 reis	Gold........	0	54	5
British Amer ...	Dollar........	Gold........	1	0	0
Bogota	Peso	Gold........	0	96	5
Central Amer...	Dollar........	Silver.......	0	91	8
Chili	Peso	Gold........	0	91	2
Cuba	Peso	Gold........	0	92	5
Denmark.......	Crown	Gold.......	0	26	8
Ecuador	Dollar........	Silver.......	0	91	8
Egypt	Pound of 100 piasters	Gold........	4	97	4
France.........	Franc	Gold & Silver	0	19	3
Gt. Britain	Pound sterling	Gold........	4	86	6¼
Greece	Drachma	Gold & Silver	0	19	3
German Emp ...	Mark	Gold........	0	23	8
India	Rupee, 16 an..	Silver.......	0	43	6
Italy	Lira..........	Gold & Silver	0	19	3
Japan	Yen	Gold........	0	99	7
Liberia	Dollar........	Gold........	1	0	0
Mexico	Dollar........	Silver.......	0	99	8
Neitherlands ...	Florin	Silver.......	0	38	5
Norway	Crown..	Gold........	0	26	8
Paraguay	Peso	Gold........	1	0	0
Peru	Sol....	Silver.......	0	96	0

THE MONETARY UNITS—Continued.

Country.	Monetary Units.	Standard.	Value.
Porto Rico.....	Peso	Gold........	0 92 5
Portugal.......	Mil. 1000 r's ..	Gold........	1 8 0
Russia	Rubles, 100 co	Silver.......	0 73 4
Sandwich Islands	Dollar........	Gold........	1 0 0
Spain..........	Peseta of 100 centimes ...	Gold & Silver	0 19 3
Sweden	Crown	Gold........	0 26 8
Switzerland	Franc	Gold & Silver	0 19 3
Tripoli.........	Mah. 20 pi's ..	Silver.......	0 82 9
Tunis..........	Pi's.. 16 car...	Silver.......	0 11 8
Turkey	Piaster	Gold........	0 4 3
Colombia.......	Peso	Silver	0 91 8
Uruguay	Patacon	Gold........	0 94 9

DIMENSIONS OF AMERICAN ENSIGNS.

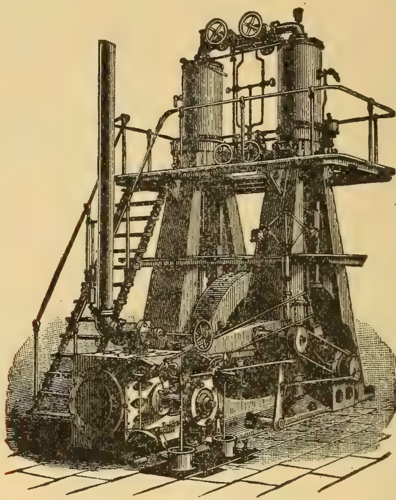
Numbers.	Head or hoist.	Whole length.	Length of union.
	Feet.	Feet.	Feet.
1	19.00	36.00	14.40
2	16.90	32.00	12.80
3	14.80	28.00	11.20
4	13.20	25.00	10.00
5	11.60	22.00	8.80
6	10.00	19.00	7.60
7	8.45	16.00	6.40
8	7.40	14.00	5.60
9	6.33	12.00	4.80
10	5.28	10.00	4.00
11	4.20	8.00	3.20
12	3.70	7.00	2.80
13	3.20	6.00	2.40
14	2.50	5.00	2.00

TO DETECT IRON FROM STEEL TOOLS.

It is diffiult to distinguish between iron and steel tools. They have the same polish and workmanship; use will commonly show the difference. To make the distinction quickly, place the tool upon a stone, and drop upon it some diluted nitric acid, four parts of water to one of acid. If the tool remains clean, it is of iron; if of steel, it will show a black spot where touched with the acid. These spots can be easily rubbed off.

ARTIFICIAL ICE-MAKING.

Reduced to the fewest words, the scientific principle underlying all methods for making artificial ice is that whenever a liquid is evaporated it takes up more or less heat from surrounding objects. This fact can be easily demonstrated by any one. Stick your finger in your mouth and moisten it with saliva. Then hold the wet finger in the wind. At once that finger feels colder than the rest, for the moving air takes up or evaporates the moisture, and the skin gives up



some of its heat. It is an old scientific trick to freeze water in a fire by wrapping the bottle with a rag soaked in ether or chloroform. The heat of the fire evaporates the highly volatile ether so quickly that the ether sucks all of the heat out of the water and freezes it. This is practically what the ice maker does, only he uses ammonia or sulphurous oxide instead of ether, and works on a large scale with large pumps, engines and miles of iron pipe.

At ordinary temperature, ammonia is a vapor or gas. The common ammonia sold in drug stores is really ammonia water made by saturating water with ammonia gas. The ammonia commonly used in ice-making is anhydrous ammonia, which is liquid ammonia without any water in it. There are many kinds of ice-making machines made, but all practically work on the same principle.

The principal part of the plant is the compressor pump. Then follows the condenser, the expansion coils and the receiver. The anhydrous ammonia is received by the ice-maker in oblong iron drums containing 100 pounds or more, and it is fed into the pump through a small pipe to the suction valve at the lower end of the pump, whether it be single or double acting. The pump performs a double office, for with one stroke of the piston it sucks in the anhydrous ammonia, and on the return stroke compresses the gas to a liquid, for the anhydrous ammonia is used over and over again, first as liquid, then as an expanding gas freezing the liquid, and then back as a liquid again. The ammonia gas is liquified not only by pressure but by cold. The pump forces the gas into the condenser first. This is a series of coils of small pipe over which cold water is constantly flowing. The gas pressed into the smaller pipes is condensed to liquid ammonia. As it condenses, the liquid ammonia flows into a storage tank through small pipes leading from the condenser. The pressure from the pump and suitable check valves force the liquid ammonia from the storage tank, which lies in a horizontal position, into two large vertical cylinders, and from them into the expansion coils which lie in the bottom of the freezing tanks.

The pipes of the expansion coil are much larger than the pipes in the condenser, and here the liquid ammonia expands or turns to vapor again, and as it evaporates it takes the heat from the salt brine in the tank and reduces its temperature from 18° above to 10° below zero, depending on the flow of the gas. The compressor pump, by forcing the liquid ammonia from it and sucking the gas towards it, keeps the anhydrous ammonia moving along constantly, and it goes into the receiver, from which it is pumped to be compressed and chilled into a liquid again.

The ice factories which use sulphurous oxide instead of anhydrous ammonia have a brine made from magnesium chloride instead of common salt, but in other respects the

system is about the same. The anhydrous ammonia and sulphurous oxide processes are called the compression system. In the absorption system the liquid is first heated in a boiler and the vapor which is generated is made up of about 9 parts of ammonia gas and 1 part of steam. This vapor first passes through a condenser, where the steam is turned into water again, but as the temperature is not low enough to liquify the ammonia gas, it is forced along by the boiler pressure to another condenser. Here the gas is condensed to a liquid, and then passes on to the expansion coils just as it does in the compression system. After doing its work, the gas is brought back to the "absorber," where it is taken up by water again and pumped back into the boiler.

In making artificial ice, the manufacturer wants pure water. To be certain that the water is free from sediment and typhoid germs, he filters and distils the water before it is frozen. In some ice works the water is filtered once before it is distilled, and twice afterwards. The freezing tanks are made of iron. They usually are set below the floor for the purpose of facilitating the handling of ice. The average tank is about 50 feet long, 20 feet wide and 4 feet deep. The cans in which the distilled water is frozen are 44 inches by 22 inches by 11 inches in size.

The pipes which carry the anhydrous ammonia go back and forth across the tank between the cans, and the salt water brine is kept in motion by an agitator something like a screw propeller. This gives the brine an even temperature. It requires from 34 to 60 hours to freeze a 300-pound cake of ice. Over the freezing tank is a traveling crane with a block and tackle for hoisting the cans with the frozen blocks out of the tank. The cans are lifted. so that when clear of the tank they tilt upside down. Streams of tepid water are directed on the can, and in a short time the cake of ice slips out of the can and slides down the gangway to the ice-house.

Nearly every brewery in the country has its own refrigerating plant. For cooling cellars, vaults and other parts of the brewery, chilled brine is pumped through pipes. Sometimes, however, as in the direct expansion method, the expansion pipes are used. Both methods are also employed in chemical works, cold storage warehouses and packing houses. Ice machines are rated with capacities varying from 50 to 100 tons of ice a day. They are built vertical and hori-

zontal, single and duplicate, operated either direct or from an engine.

NOVEL USES OF COMPRESSED AIR.

Most people think that compressed air is only used for automatic car-brakes and rock drills. The fact is, compressed air as an agent for transmitting energy and power is pushing electricity hard and, on some lines, has distanced steam.

On many railroads compressed air has taken the place of whisk brooms and beaters for cleaning seat cushions of passenger cars. The air at 50 to 75 pounds pressure to the square inch is brought into the car through an air hose which has a brass air nozzle on the end. The women handle this nozzle as though water instead of compressed air were coming through, and the air jet drives the dust, cinders and dirt out of the cushions quicker and better than any other method.

In the new criminal court building of Chicago, a system of pneumatic clocks has been installed. The "master" clock sends pulsations of compressed air through small pipes to the connecting clocks, and thus all run on the same time and are regulated together.

In several machine shops in the country there is not a belt or a piece of shafting outside of the engine-room. Instead, pipes run from the compressed air reservoir to compressed air motors. Each drill, lathe, reamer, milling machine, emery wheel, bending rolls, punch, drop hammer and press has its individual air motor or engine, and the mere turning of a throttle valve starts or stops the machine.

The pneumatic clock system was installed first in Paris about 1870. From it grew the present compressed air central-power system, which supplies over 10,000 horse-power to users in the French capital. It is there used for all purposes, from running clocks to operating dynamos for electric lights. The central station furnishes air at a pressure of 75 pounds to the square inch.

Asphalt used for street-paving is refined by compressed air. In its original shape, just as it comes from Trinidad, asphalt is too soft for street-paving, and is not homogeneous To refine it, the asphalt is boiled in kettles for three or four days, and while the heat is on it must be stirred. Pipes hav-

ing numerous holes are placed in the bottom of the kettle, and while the asphalt is boiling, compressed air is forced through the pipes and, escaping through the holes, agitates the thick black material, thus refining it.

Compressed air was the paint-brush which placed the color on the World's Fair buildings in Chicago, and which to-day is painting railroad bridges and corrugated iron plates for buildings. The compressed air not only draws the liquid paint from the tubs or buckets, but sprays it over the surface and drives it into the wood.

In the big shipyards, where the government vessels are built, all the calking is done by compressed air, and one compressed air calking machine does the work of four men. This calker strikes 1,000 blows a minute. The same tool is used by boiler-makers, and, in a modified form, by stonecutters for dressing and carving stone. The little engine which does the work is in the handle of the tool which is about the size of a large chisel handle. The air is brought to the tool by a small rubber pipe, which is so flexible it can be handled easily and at any angle. A piston and spring shove the tool in and out, and it can be so adjusted that the heaviest or most delicate work can be done with it.

Acids which would eat a pump up at once, are raised by compressed air. Sewage which is below the level of the sewer is forced up by compressed air. Impure water is cleaned, gold and silver are dug from mines, letters are copied in the letter press, elevator signal bells are rung, cattle are lifted after being killed in slaughter houses, furnace grates are shaken, crude oil is atomized under steam boilers, grain is cleaned, and a hundred other things are daily done by compressed air.

CONCERNING ELECTRIC BATTERIES.

In a general way batteries are divided into two classes—open circuit batteries and closed circuit batteries. In all kinds of batteries the electro-motive force decreases and the internal resistance increases when working on a circuit of low resistance. This is caused by "polarization," which is the collecting of tiny bubbles of hydrogen gas on the negative plate due to the action of the current. These bubbles covering the negative plate not only diminish the working surface of the plate, and thus reduces the electro-motive

force, but increases the resistance. In this condition the battery is said to be polarized. To correct this evil various chemicals, either fluid or solid are placed in the battery to generate oxygen which may unite with the hydrogen. Such chemicals are called "depolarizers." Those batteries in which the depolarizers act slowly and after the battery has stopped work are called "open circuit"; that in which the depolarizers is working is "closed circuit." The open circuit battery is used where the demand for the current is intermittant; the "closed circuit battery" is used where the current is required almost continuously.

Batteries should be kept where the temperature is about even, avoiding extremes of heat or cold. They should be carefully protected from dust and dirt. The cells should be covered so as to prevent rapid evaporation of the solution. The best place for batteries is a dry cool place.

Where zinc is used in a battery the plate should be rolled and not cast zinc. The carbon plates should be solid, fine and hard. Those made from gas-retort carbon. The upper part of carbon rods should be dipped in melted paraffiine until the wax has soaked in, say to an inch or so from the top. This will keep the solution from "creeping" or crawling up, as it will do unless the rod is waxed. Before a zinc rod is placed in a battery it should first be thoroughly brightened by scouring it with weak sulphuric acid, and then a small portion of mercury should be rubbed over it. The amalgamation will prevent what is known as "local action." Sal-ammoniac, if used, should be pure, otherwise the battery will become dirty. Porus cups should be soaked in water and then thoroughly scrubbed out. Carbon plates, in renewing batteries, should be treated in the same way. Batteries should never be neglected if good work from them is desired. A poor battery is often worse than no battery at all, and it is false economy to re-charge with impure and therefore cheap chemicals.

HOW BOILER PLATES ARE PROVED.

This is done by placing a piece of Bessmer steel 10 inches long in a testing machine. Gradually the surface scales off in the middle, to become smaller in area, and somewhat elongated, til, at last, it breaks with a sharp snap at a breaking strain of about 28 tons to the square inch, the reduction of area being 51 per cent, and the elongation 23 per cent.

DIFFERENCES OF TIME FROM NEW YORK.

At any Given Time in New York it is in—

	HRS.	MIN.	SEC.	
Amsterdam (Holland)................	5	16		later.
Berne (Switzerland)....................	5	26		"
Berlin (Prussia)........................	5	49	35	"
Brussels (Belgium).....................	5	13	30	"
Buda Pesth (Hungary)..................	6	12		"
Carlsruhe (Baden)......................	5	30		"
Christiania (Norway)...................	5	39		"
Cologne (Germany)......................	5	24		"
Constantinople (Turkey)................	6	52		"
Copenhagen (Denmark)	5	46		"
Dublin (Ireland).........................	4	30	30	"
Frankfort (Germany)....................	5	30		"
Geneva (Switzerland)...................	5	20	30	"
Gothenburg (Sweden)....................	5	45		"
Greenwich (England)....................	4	56		"
Hamburg (Germany)......................	5	36		"
Lisbon (Portugal).......................	4	19	30	"
London (England).......................	4	55	56	"
Madrid (Spain)...........................	4	4[illegible]	15	"
Moscow (Russia)........................	7	26		"
Munich (Bavaria)........................	5	42	30	"
Naples (Italy)...........................	5	53		"
Paris (France)...........................	5	05	15	"
Prague (Austria)........................	5	54		"
Rome (Italy)............................	5	46		"
St. Petersburg (Russia).................	6	57		"
Stuttgart (Würtemberg).................	5	33		"
Stockholm (Sweden).....................	6	08		"
Trieste (Austria).......................	5	51		"
Venice (Italy)..........................	5	45	30	"
Vienna (Austria.........................	6	01	33	"
Warsaw (Poland).........................	6	20		"

The differences are at the rate of one hour for every fifteen degrees of longitude, or four minutes for each degree.

A VALUABLE PRESERVATIVE PAINT.

Soapstone incorporated with oil, after the manner of paint, is said to be superior to any kind of a paint as a preservative. Soapstone is to be had in an exceedingly fine powder, mixes readily with prepared oils for paint, which covers well surfaces of iron, steel, or stone, and is an effectual remedy against rust.

TIME AT DIFFERENT PLACES, WHEN IT IS 12 O'CLOCK AT NEW YORK CITY; ALSO, DIFFERENCE IN TIME FROM NEW YORK.

New York City 12 M.					Fast.			Slow.		
Places.	H	M	S		H	M	S	H	M	S
Albany, N. Y.	12	1	1	p.m		1	1			
Annapolis, Md.	11	50	4	a.m.					9	56
Augusta, Me.	12	16	40	p.m		16	40			
Baltimore, Md.	11	49	33	a.m.					10	27
Bangor, Me.	12	20	52	p.m		20	52			
Boston Mass.	12	11	46	"		11	46			
Buffalo, N. Y.	11	40	20	a.m.					19	40
Charleston, S. C.	11	36	18	"					23	42
Chicago, Ill.	11	5	29	"					54	31
Cincinnati, O.	11	18	2	"					41	58
Cleveland, O.	11	28	36	"					31	24
Columbus, O.	11	23	48	"					36	12
Concord, N. H.	12	10	4	p.m		10	4			
Detroit, Mich.	11	23	50	a.m.					36	10
Eastport, Me.	12	28	16	p.m		28	16			
Fall River, Mass.	12	11	32	"		11	32			
Frankfort, Ky.	11	17	20	a.m.					42	40
Halifax, N. S.	12	41	33	p.m		41	33			
Harrisburg, Pa.	11	48	40	a.m.					11	20
Hartford, Conn.	12	5	17	p.m		5	17			
Key West, Fla.	11	28	50	a.m.					31	10
Leavenworth, Kan	10	37	4	a.m.				1	22	56
Lexington, Ky.	11	18	48	"						
Liverpool, Eng.	4	43	56	p.m	4	43	56		41	12
Louisville, Ky.	11	14		a.m.					46	
Lowell, Mass.	12	10	44	p.m		10	44			
Memphis, Tenn.	10	55	28	a.m.				1	4	32
Milwaukee, Wis.	11	4	23	"					55	37
Montpelier, Vt.	12	5	36	p.m		5	36			
Montreal, Que.	12	1	48	"		1	48			
New Orleans, La.	10	56		a.m.				1	4	
Niagara Falls, N. Y.	11	39	44	"					20	16
Norfolk, Va.	11	50	46	"					9	14
Omaha, Neb.	10	32	4	"				1	27	56

TIME AT DIFFERENT PLACES.—Continued.

New York City 12 M.					Fast.			Slow.		
Places.	H	M	S		H	M	S	H	M	S
Oswego, N. Y.	11	49	36	"					10	24
Paris, France	5	5	21	p.m	5	5	21			
Philadelphia, Pa.	11	55	20	a.m.					4	40
Pike's Peak, Col.	9	56		"				2	4	
Pittsburg, Pa.	11	35	52	"					24	8
Portland, Me.	12	15	2	p.m		15	2			
Providence, R. I.	12	10	25	"		10	25			
Quebec, Que	12	11	11	"		11	11			
Raleigh, N. C.	11	40	48	a.m.					19	12
Richmond, Va.	11	46	10	"					13	50
Sacramento, Cal.	8	50	9	"				3	9	51
Salt Lake City, Utah	9	27	36	"				2	32	24
San Francisco, Cal.	8	46	13	"				3	13	47
Savannah, Ga.	11	31	39	"					28	21
Springfield, Mass.	12	5	37	p.m		5	37			
St. Louis, Mo.	10	54	59	a m.				1	5	1
Syracuse, N. Y.	11	51	12	"					8	48
Toronto, Ont.	11	38	27	"					21	33
Trenton, N. J.	11	57	24	"					2	36
Washington, D. C.	11	47	48	"					12	12

LENGTH AND NUMBER OF TACKS TO THE POUND.

Title.	Length.	No. p. lb.	Title.	Length.	No. p. lb.
1 oz.	1/8 in.	16,000	10 oz.	11-16	1,600
1½ "	3-16 "	10,666	12 "	¾	1,333
2 "	¼ "	8,000	14 "	13-16	1,143
2½ "	5-16 "	6,400	16 "	⅞	1,000
3 "	⅜ "	5,333	18 "	15-16	888
4 "	7-16 "	4,000	20 "	1	800
6 "	9-16 "	2,666	22 "	11-16	727
8 "	⅝ "	2,000	24 "	1⅛	666

SWITCHING FROM THE ENGINE CAB.

A device that will enable the engineer, from his cab, to switch his locomotive at pleasure, while the conductor on the caboose or rear car closes the switch again, would surely be a novelty in railroading, amounting to a revolution. Yet a Cleveland inventor claims to have solved the problem, and to be able to demonstrate its practicability with a working model. Not to go into the details, it may be sufficient to say that the "central throw" switch is shifted by a double-flanged shoe, of any length, dropped from beneath any front or rear truck, while the train is in motion, first overthrowing the crank that draws the lock-plate off the fixed rail, then moving the lug of the angle connected with the fly-rail to the right or left, as indicated by the target on the engine or caboose, after which the lock slides forward and grasps the fixed rail, holding the "fly" in alignment, making a continuous rail. Thus, a switch is carelessly left open, and a passenger train is approaching. The engineer detects the danger; the improvised "shoe" is dropped to the rail; it strikes the lug, the switch is closed, and, a collision avoided. On the other hand, a train may be side-tracked by the same simple operation from the cab. Of course, this would do away with switchmen and frog accidents, and a great many other disadvantages incident to the present method, should the invention come into practical use. This, necessarily is yet to be demonstrated by actual test, under varying conditions, before success can be confidently claimed; but the device is certainly of general interest.

ELECTRIC LIGHTING.

In an address before the Montauk Club of Brooklyn, Mr. Charles W. Price stated that over $600,000,000 had been invested in electric lighting in the United States; and that the total horse power required in the electric lighting of Greater New York was not less than 200,000 horse power; that in the last thirteen years since the birth of the electric railway there had been an expenditure of more than $1,700,000,000, and that now any one could travel by electric cars from Paterson, N. J., via New York, to Portland, Maine, with only three insignificant interruptions which collectively amount to less than fifteen miles.

Between Chicago and Milwaukee, a distance of 85 miles, a series of trolley lines connect the two cities by electric cars.

MANILLA ROPE TRANSMISSION.

A four-strand, hard-laid manilla rope, having a core, or "heart-yarn," is probably the best rope for transmission purposes, although three-strand rope is generally recommended, says a writer in the *American Miller*. Of course it is important to have the rope laid in tallow, as that greatly prolongs its life. The matter of splice is also important. Seamen all agree that the long splice is the best, but the experience of rope-transmission men is almost universally in favor of a short splice. The length of a long splice in an inch diameter rope will be five or six feet, while a short one is two and two and a half feet. I think this is what the sailors term "a short splice." I have seen a short splice succeed where long ones have repeatedly failed. I have known of a manilla rope used out of doors being painted with oil, and then varnished. It seems to work well. Tar is certainly unsuitable as a dressing for transmission rope. In the first place it weakens it; in the second, its sticking to the pulley or sheave would be a detriment rather than an improvement. There is no difficulty about the ropes sticking on the sheave, if properly designed and constructed.

SAFE WORKING PRESSURE FURNACE FLUES.

In a report to his company, the chief engineer of the Engine, Boiler and Employers' Liability Insurance Company, purposes the following rule for the safe-working pressure for cylindrical furnaces in flues: Safe-working pressure

$$= \frac{50t^2 \quad d}{\sqrt{ld} \quad l}$$

where

t=thickness of plate in thirty-second of an inch.
l=length of flue in feet.
d=diameter in inches.

RIVETLESS STEEL SLEEPERS.

Mr. H. Hipkins has invented a rivetless steel sleeper for railroads. The lips or jaws for holding the rails in place are stamped out of the solid plate, and are stiffened by corrugations or brackets, which are also raised from the solid plate out of the hollow at the back of each jaw. A center strip is provided for the rail to rest upon, dispensing with all rivets and loose parts. These sleepers can be laid rapidly, and they are claimed to be especially adapted to use underground in mines

TAKE CARE OF YOUR AUTOMATIC SPRINKLERS.

Many business blocks, workshops, stores, etc., have been expensively fitted up with automatic sprinklers as a safeguard against fires, a certain temperature of heat fusing the metal, opening a valve and letting on a flow of water. But an inspection of the perforated pipes in a majority of instances will reveal the fact that the apparatus has been neglected. Cobwebs and dust cover the pipes, the sprinklers have been permitted to corrode and unsolder, and, should a fire chance to occur and the friendly services of the sprinklers ever be required, they would be found almost useless, and for all the work they would perform in the line of throwing cold water on the devouring elements, the premises might as well have remained "unprotected."

HOW TO OVERCOME VIBRATION.

How to put the smith shop in an upper story without having the working on the anvils jar the building, has been a problem that has frequently given manufacturers trouble. A mechanical engineer says it may be safely done by placing a good heavy foundation of sheet lead on the floor, and on that putting a good thickness of rubber belting.

Another person who is interested in the problem has tried the experiment, with some success, of placing the block, not on the floor, but on the joist direct, making a cement floor up to the block, and over the wooden floor, reaching back beyond the reach of sparks. It is sometimes said that blacksmith shops never burn, but they keep right on burning in spite of theory, and cement floors ought to be helpful in guarding against fires.

SAWMILL OPERATED BY AIR.

The only sawmill in the world where the machiney is operated by compressed air is located in Oronto, Me., and the water wheel and the air compressor are below the floor of the mill, with also large storage tanks. Pipes lead the air to the various machines, which technically are known as the carriage, nigger, log-leader, log-flipper, band log-saw and two cut-off saws.

ALLOYS.	Tin.	Copper.	Zinc.	Antimony.	Lead.	Bismuth.
Brass engine bearings........	13	112	¼	....	....	....
Tough brass, engine work.....	15	100	15	....	....	....
" for heavy bearings....	25	160	5	....	....	....
Yellow brass, for turning.....	....	2	1	....	....	....
Flanges to stand brazing.....	....	32	1	....	1	....
Bell metal..................	5	16	....	....	....	....
Babbitt's metal.............	10	1	....	1	....	....
Brass locomotive bearings....	7	64	1	....	....	....
" for straps and glands..	16	130	1	....	....	....
Muntz's sheathing..........	....	6	4	....	....	....
Metal to expand in cooling...	...	....	....	2	9	1
Pewter....................	100	....	....	17	....	....
Spelter....................	....	1	1	....	....	....
Statuary bronze.............	2	90	5	....	2	....
Type metal.............from	....	....	....	1	3	....
" ....to	....	...	....	1	7	....
SOLDERS.						
For lead..................	1	....	....	....	1½	....
" tin.....................	1	....	....	....	2	....
" pewter..................	2	....	....	....	1	....
" brazing (hardest)........	....	3	1	....	....	....
" " (hard)...........	....	1	1	....	....	....
" " (soft)...........	1	4	3	....	....	....
" " "	2	....	....	1	....	....

HOW TO MAKE HARD AND DUCTILE BRASS CASTINGS.

Two per cent. by weight of finely pounded bottle glass, placed at the bottom of the crucible in which red brass is being melted for castings, gives great hardness, and at the same time ductility to the metal. Porous castings are said to be almost an impossibility when this is done, and the product is likely to be of great service in parts of machinery subject to strain. An addition of one per cent. of oxide of manganese facilitates working in the lathe and elsewhere where great hardness might be an objection.

DECIMAL EQUIVALENTS
of 8ths, 16ths, 32ds and 64ths of an Inch.

Fractions of an Inch.	Decimals of an Inch.	Fractions of an Inch.	Decimals of an Inch.
1-64	= .015625	33-64	= .515625
1-32	= .03125	17-3	= .53125
3-64	= .046875	35-64	= .546875
1-16	= .0625	9-16	= .5625
5-64	= .078125	37-64	= .578125
3-32	= .09375	19-32	= .59375
7-64	= .109375	39-64	= .609375
⅛	= .125	⅝	= .625
9-64	= .140625	41-64	= .640625
5-32	= .15625	21-32	= .65625
11-64	= .171875	43-64	= .671875
3-16	= .1875	11-16	= .6875
13-64	= .203125	45-64	= .703125
7-32	= .21875	23-32	= .7185
15-64	= .234375	47-64	= .734375
¼	= .5	¾	= .75
17-64	= .265625	49-64	= .765625
9-32	= .28125	25-32	= .78125
19-64	= .296875	51-64	= .796875
5-16	= .3125	13-16	= .8125
21-64	= .328125	53-64	= .828125
11-32	= .34375	27-32	= .84375
23-64	= .359375	55-64	= .859375
⅜	= .375	⅞	= .875
25-64	= .390625	57-64	= .89625
13-32	= .40625	29-32	= .90625
27-64	= .421895	59-64	= .92187
7-16	= .4375	15-16	= .9375
29-64	= .453125	61-64	= .953125
15-32	= .46875	31-32	= .96875
31-64	= .484375	63-64	= .984375
½	= .5		

HOW TO ANNEAL SMALL TOOLS.

A very good way to anneal a small piece of tool steel is to heat it up in a forge as slowly as possible, and then take two fireboards and lay the hot steel between them and screw them in a vice. As the steel is hot, it sinks into the pieces of wood, and is firmly imbedded in an almost air-tight charcoal bed, and when taken out cold will be found to be nice and soft. To repeat this will make it as soft as could be wished.

AN EXPERIMENT WITH A LOCOMOTIVE.

A locomotive engineer who takes an intelligent interest in operating his engine economically, relates the particulars of runs where careful efforts were made to test the difference in the consumption of coal that resulted with the reverse lever hooked back as far as practicable and the throttle full open, and running with a late cut-off, and the steam throttled, or the difference between throttling and cutting off short.

First Case—A train of 19 loaded and 12 empty cars, rated at 25 loads. Run from Mansfield to Lodge, distance, 8.6 miles, nearly level. Forced the train into speed, and then pulled the reverse lever to the center notch, and opened the throttle wide. The engine jarred a good deal, due, doubtless, to the excessive compression, but the speed was maintained. Twenty-two minutes were occupied by the run, a speed of 23 miles per hour, and 17 shovelfuls of coal were consumed in keeping up steam. By weighing, it was found a shovelful averaged 14 pounds, making the coal used per train mile average 27.7 pounds.

Second Case— A train of 25 loads and six empties, rated as 28 loaded cars. Ran, as in the first case, from Mansfield to Lodge. Pulled the train into speed in as nearly as possible the same time as in the previous test, but, when the speed was attained, kept the reverse lever in the nine-inch notch, and throttled the steam to keep down the speed. Although the train was rated two loads heavier than the previous one, it consisted mostly of merchandise, while the other was heavy freight, and handled decidedly easier. Having pulled both trains over 40 miles before arriving at Mansfield, there was full means of judging which was the easier train to handle.

The run was made in 24 minutes, two minutes longer than in the other case, and 32 shovelfuls of coal were used, being at the rate of 52 pounds per train mile. In both instances the fire was as nearly as possible the same depth at the beginning and end of the run.

Our correspondent thus concludes his narrative: "It is interesting to know that on the first occasion 238 pounds of coal were used to do the same work in less time than 448 pounds were required to do under the changed circumstances of the second trip; showing that a gain of 88 per cent. may be effected by running with full throttle and early cut off."

THE MORSE CODE.

As all moto-vehicles must be furnished with a sound-producing instrument, either a whistle, horn or bell, as well as with lamps, automobilists are readily ènabled by the Morse code to signal or send a message, either by sound or by flashing signals, a considerable distance. Apart from this. a knowledge of the Morse is invaluable to the traveller, soldier, and seaman.

A · —	J · — — —	S · · ·
B — · · ·	K — · —	T —
C — · — ·	L · — · ·	U · · —
D — · ·	M — —	V · · · —
E ·	N — ·	W · — —
F · · — ·	O — — —	X — · · —
G — — ·	P · — — ·	Y — · — —
H · · · ·	Q — — · —	Z — — · ·
I · ·	R · — ·	

Numerals.

1	. 4	7
· — — — —	· · · · —	— — · · ·
2	5	8
· · — — —	· · · · ·	— — — · ·
3	6	9
· · · — —	— · · · ·	— — — — ·
	0	
	— — — — —	

LIQUID FUEL BURNERS.

These are mainly of two distinct types: gasifiers and sprayers. In the former the fuel, usually a heavy liquid hydrocarbon, flows into a chamber called a vaporiser, upon which impinges a flame. The liquid is converted into a liquid vapor or gas which burns in the free presence of air with a yellow flame, or it can be mixed with air as in a Bunsen burner, when a blue flame is produced.

A WARNING TO ENGINEERS.

Never take the cap off a bearing and remove the upper brass to see if things are working well, for you never can replace the brass exactly in its former position, and you will find that the bearing will heat soon afterward, on account of your unnecessary interference. If there is any trouble, you will find it out soon enough.

WEIGHT AND AREAS OF
SQUARE & ROUND BARS OF WROUGHT IRON
And Circumference of Round Bars.

One cubic foot weighing 480 lbs.

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
0					
1/16	.013	.010	.0039	.0031	.1963
1/8	.052	.041	.0156	.0123	.3927
3/16	.117	.092	.0352	.0276	.5890
1/4	.208	.164	.0625	.0491	.7854
5/16	.326	.256	.0977	.0767	.9817
3/8	.469	.368	.1406	.1104	1.1781
7/16	.638	.501	.1914	.1503	1.3744
1/2	.833	.654	.2500	.1963	1.5708
9/16	1.055	.828	.3164	.2485	1.7671
5/8	1.302	1.023	.3906	.3068	1.9635
11/16	1.576	1.237	.4727	.3712	2 1598
3/4	1.875	1.473	.5625	.4418	2 3562
13/16	2.201	1.728	.6602	.5185	2.5525
7/8	2.552	2.004	.7656	.6013	2.7489
15/16	2.930	2.301	.8789	.6903	2.9452
1	3.333	2.618	1.0000	.7854	3.1416
1/16	3.763	2.955	1.1289	.8866	3.3379
1/8	4.219	3.313	1.2656	.9940	3 5343
3/16	4.701	3.692	1.4102	1 1075	3.7306
1/4	5.208	4.091	1.5625	1.2272	3.9270
5/16	5.742	4.510	1 7227	1.3530	4.1233
3/8	6.302	4.950	1.8906	1.4849	4.3197
7/16	6.888	5.410	2.0664	1.6230	4.5160
1/2	7.500	5.890	2.2500	1 7671	4 7124
9/16	8.138	6.392	2.4414	1.9175	4.9087
5/8	8.802	6.913	2.6406	2.0739	5.1051
11/16	9.492	7.455	2.8477	2.2365	5.3014
3/4	10.21	8.018	3.0625	2.4053	5.4978
13/16	10.95	8.601	3.2852	2.5802	5.6941
7/8	11.72	9.204	3.5156	2.7612	5.8905
15/16	12.51	9.828	3.7539	2.9483	6.0868

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
2	13.33	10.47	4.0000	3.1416	6.2832
$\frac{1}{16}$	14.18	11.14	4.2539	3.3410	6.4795
$\frac{1}{8}$	15.05	11.82	4.5156	3.5466	6.6759
$\frac{3}{16}$	15.95	12.53	4.7852	3.7583	6.8722
$\frac{1}{4}$	16.88	13.25	5.0625	3.9761	7.0686
$\frac{5}{16}$	17.83	14.00	5.3477	4.2000	7.2649
$\frac{3}{8}$	18.80	14.77	5.6406	4.4301	7.4613
$\frac{7}{16}$	19.80	15.55	5.9414	4.6664	7.6576
$\frac{1}{2}$	20.83	16.36	6.2500	4.9087	7.8540
$\frac{9}{16}$	21.89	17.19	6.5664	5.1572	8.0503
$\frac{5}{8}$	22.97	18.04	6.8906	5.4119	8.2467
$\frac{11}{16}$	24.08	18.91	7.2227	5.6727	8.4430
$\frac{3}{4}$	25.21	19.80	7.5625	5.9396	8.6394
$\frac{13}{16}$	26.37	20.71	7.9102	6.2126	8.8357
$\frac{7}{8}$	27.55	21.64	8.2656	6.4918	9.0321
$\frac{15}{16}$	28.76	22.59	8.6289	6.7771	9.2284
3	30.00	23.56	9.0000	7.0686	9.4248
$\frac{1}{16}$	31.26	24.55	9.3789	7.3662	9.6211
$\frac{1}{8}$	32.55	25.57	9.7656	7.6699	9.8175
$\frac{3}{16}$	33.87	26.60	10.160	7.9798	10.014
$\frac{1}{4}$	35.21	27.65	10.563	8.2958	10.210
$\frac{5}{16}$	36.58	28.73	10.973	8.6179	10.407
$\frac{3}{8}$	37.97	29.82	11.391	8.9462	10.603
$\frac{7}{16}$	39.39	30.94	11.816	9.2806	10.799
$\frac{1}{2}$	40.83	32.07	12.250	9.6211	10.996
$\frac{9}{16}$	42.30	33.23	12.691	9.9678	11.192
$\frac{5}{8}$	43.80	34.40	13.141	10.321	11.388
$\frac{11}{16}$	45.33	35.60	13.598	10.680	11.585
$\frac{3}{4}$	46.88	36.82	14.063	11.045	11.781
$\frac{13}{16}$	48.45	38.05	14.535	11.416	11.977
$\frac{7}{8}$	50.05	39.31	15.016	11.793	12.174
$\frac{15}{16}$	51.68	40.59	15.504	12.177	12.370

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
4	53.33	41.89	16.000	12.566	12.566
$\frac{1}{16}$	55.01	43.21	16.504	12.962	12.763
$\frac{1}{8}$	56.72	44.55	17.016	13.364	12.959
$\frac{3}{16}$	58.45	45.91	17.535	13.772	13.155
$\frac{1}{4}$	60.21	47.29	18.063	14.186	13.352
$\frac{5}{16}$	61.99	48.69	18.598	14.607	13.548
$\frac{3}{8}$	63.80	50.11	19.141	15.033	13.744
$\frac{7}{16}$	65.64	51.55	19.691	15.466	13.941
$\frac{1}{2}$	67.50	53.01	20.250	15.904	14.137
$\frac{9}{16}$	69.39	54.50	20.816	16.349	14.334
$\frac{5}{8}$	71.30	56.00	21.391	16.800	14.530
$\frac{11}{16}$	73.24	57.52	21.973	17.257	14.726
$\frac{3}{4}$	75.21	59.07	22.563	17.721	14.923
$\frac{13}{16}$	77.20	60.63	23.160	18.190	15.119
$\frac{7}{8}$	79.22	62.22	23.766	18.665	15.315
$\frac{15}{16}$	81.26	63.82	24.379	19.147	15.512
5	83.33	65.45	25.000	19.635	15.708
$\frac{1}{16}$	85.43	67.10	25.629	20.129	15.904
$\frac{1}{8}$	87.55	68.76	26.266	20.629	16.101
$\frac{3}{16}$	89.70	70.45	26.910	21.135	16.297
$\frac{1}{4}$	91.88	72.16	27.563	21.648	16.493
$\frac{5}{16}$	94.08	73.89	28.223	22.166	16.690
$\frac{3}{8}$	96.30	75.64	28.891	22.691	16.886
$\frac{7}{16}$	98.55	77.40	29.566	23.221	17.082
$\frac{1}{2}$	100.8	79.19	30.250	23.758	17.279
$\frac{9}{16}$	103.1	81.00	30.941	24.301	17.475
$\frac{5}{8}$	105.5	82.83	31.641	24.850	17.671
$\frac{11}{16}$	107.8	84.69	32.348	25.406	17.868
$\frac{3}{4}$	110.2	86.56	33.063	25.967	18.064
$\frac{13}{16}$	112.6	88.45	33.785	26.535	18.261
$\frac{7}{8}$	115.1	90.36	34.516	27.108	18.457
$\frac{15}{16}$	117.5	92.29	35.254	27.688	18.653

SQUARE AND ROUND BARS.

(CONTINUED)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar. in inches.
6	120.0	94.25	36.000	28.274	18.850
1/16	122.5	96.22	36.754	28.866	19.046
1/8	125.1	98.22	37.516	29.465	19.242
3/16	127.6	100.2	38.285	30.069	19.439
1/4	130.2	102.3	39.063	30.680	19.635
5/16	132.8	104.3	39.848	31.296	19.831
3/8	135.5	106.4	40.641	31.919	20.028
7/16	138.1	108.5	41.441	32.548	20.224
1/2	140.8	110.6	42.250	33.183	20.420
9/16	143.6	112.7	43.066	33.824	20.617
5/8	146.3	114.9	43.891	34.472	20.813
11/16	149.1	117.1	44.723	35.125	21.009
3/4	151.9	119.3	45.563	35.785	21.206
13/16	154.7	121.5	46.410	36.450	21.402
7/8	157.6	123.7	47.266	37.122	21.598
15/16	160.4	126.0	48.129	37.800	21.795
7	163.3	128.3	49.000	38.485	21.991
1/16	166.3	130.6	49.879	39.175	22.187
1/8	169.2	132.9	50.766	39.871	22.384
3/16	172.2	135.2	51.660	40.574	22.580
1/4	175.2	137.6	52.563	41.282	22.777
5/16	178.2	140.0	53.473	41.997	22.973
3/8	181.3	142.4	54.391	42.718	23.169
7/16	184.4	144.8	55.316	43.445	23.366
1/2	187.5	147.3	56.250	44.179	23.562
9/16	190.6	149.7	57.191	44.918	23.758
5/8	193.8	152.2	58.141	45.664	23.955
11/16	197.0	154.7	59.098	46.415	24.151
3/4	200.2	157.2	60.063	47.173	24.347
13/16	203.5	159.8	61.035	47.937	24.544
7/8	206.7	162.4	62.016	48.707	24.740
15/16	210.0	164.9	63.004	49.483	24.936

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
8	213.3	167.6	64.000	50.265	25.133
1/16	216.7	170.2	65.004	51.054	25.329
1/8	220.1	172.8	66.016	51.849	25.525
3/16	223.5	175.5	67.035	52.649	25.722
1/4	226.9	178.2	68.063	53.456	25.918
5/16	230.3	180.9	69.098	54.269	26.114
3/8	233.8	183.6	70.141	55.088	26.311
7/16	237.3	186.4	71.191	55.914	26.507
1/2	240.8	189.2	72.250	56.745	26.704
9/16	244.4	191.9	73.316	57.583	26.900
5/8	248.0	194.8	74.391	58.426	27.096
11/16	251.6	197.6	75.473	59.276	27.293
3/4	255.2	200.4	76.563	60.132	27.489
13/16	258.9	203.3	77.660	60.994	27.685
7/8	262.6	206.2	78.766	61.862	27.882
15/16	266.3	209.1	79.879	62.737	28.078
9	270.0	212.1	81.000	63.617	28.274
1/16	273.8	215.0	82.129	64.504	28.471
1/8	277.6	218.0	83.266	65.397	28.667
3/16	281.4	221.0	84.410	66.296	28.863
1/4	285.2	224.0	85.563	67.201	29.060
5/16	289.1	227.0	86.723	68.112	29.256
3/8	293.0	230.1	87.891	69.029	29.452
7/16	296.9	233.2	89.066	69.953	29.649
1/2	300.8	236.3	90.250	70.882	29.845
9/16	304.8	239.4	91.441	71.818	30.041
5/8	308.8	242.5	92.641	72.760	30.238
11/16	312.8	245.7	93.848	73.708	30.434
3/4	316.9	248.9	95.063	74.662	30.631
13/16	321.0	252.1	96.285	75.622	30.827
7/8	325.1	255.3	97.516	76.589	31.023
15/16	329.2	258.5	98.754	77.561	31.220

SQUARE AND ROUND BARS.

(CONUINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
10	333.3	261.8	100.00	78.540	31.416
$\frac{1}{16}$	337.5	265.1	101.25	79.525	31.612
$\frac{1}{8}$	341.7	268.4	102.52	80.516	31.809
$\frac{3}{16}$	346.0	271.7	103.79	81.513	32.005
$\frac{1}{4}$	350.2	275.1	105.06	82.516	32.201
$\frac{5}{16}$	354.5	278.4	106.35	83.525	32.398
$\frac{3}{8}$	358.8	281.8	107.64	84.541	32.594
$\frac{7}{16}$	363.1	285.2	108.94	85.562	32.790
$\frac{1}{2}$	367.5	288.6	110.25	86.590	32.987
$\frac{9}{16}$	371.9	292.1	111.57	87.624	33.183
$\frac{5}{8}$	376.3	295.5	112.89	88.664	33.379
$\frac{11}{16}$	380.7	299.0	114.22	89.710	33.576
$\frac{3}{4}$	385.2	302.5	115.56	90.763	33.772
$\frac{13}{16}$	389.7	306.1	116.91	91.821	33.968
$\frac{7}{8}$	394.2	309.6	118.27	92.886	34.165
$\frac{15}{16}$	398.8	313.2	119.63	93.956	34.361
11	403.3	316.8	121.00	95.033	34.558
$\frac{1}{16}$	407.9	320.4	122.38	96.116	34.754
$\frac{1}{8}$	412.6	324.0	123.77	97.205	34.950
$\frac{3}{16}$	417.2	327.7	125.16	98.301	35.147
$\frac{1}{4}$	421.9	331.3	126.56	99.402	35.343
$\frac{5}{16}$	426.6	335.0	127.97	100.51	35.539
$\frac{3}{8}$	431.3	338.7	129.39	101.62	35.736
$\frac{7}{16}$	436.1	342.5	130.82	102.74	35.932
$\frac{1}{2}$	440.8	346.2	132.25	103.87	36.128
$\frac{9}{16}$	445.6	350.0	133.69	105.00	36.325
$\frac{5}{8}$	450.5	353.8	135.14	106.14	36.521
$\frac{11}{16}$	455.3	357.6	136.60	107.28	36.717
$\frac{3}{4}$	460.2	361.4	138.06	108.43	36.914
$\frac{13}{16}$	465.1	365.3	139.54	109.59	37.110
$\frac{7}{8}$	470.1	369.2	141.02	110.75	37.306
$\frac{15}{16}$	475.0	373.1	142.50	111.92	37.503

Weight of Sheets of Wrought Iron, Steel Copper and Brass. (From Haswell.)

Weight per Square Foot. Thickness by Birmingham Gauge.

No. of Gauge.	Thickness in inches.	Iron.	Steel.	Copper.	Brass.
0000	.454	18.22	18.46	20.57	19.43
000	.425	17.05	17.28	19.25	18.19
00	.38	15.25	15.45	17.21	16.26
0	.34	13.64	13.82	15.40	14.55
1	.3	12.04	12.20	13.59	12.84
2	.284	11.40	11.55	12.87	12.16
3	.259	10.39	10.53	11.73	11.09
4	.238	9.55	9.68	10.78	10.19
5	.22	8.83	8.95	9.97	9.42
6	.203	8.15	8.25	9.20	8.69
7	.18	7.22	7.32	8.15	7.70
8	.165	6.62	6.71	7.47	7.06
9	.148	5.94	6.02	6.70	6.33
10	.134	5.38	5.45	6.07	5.74
11	.12	4.82	4.88	5.44	5.14
12	.109	4.37	4.43	4.94	4.67
13	.095	3.81	3.86	4.30	4.07
14	.083	3.33	3.37	3.76	3.55
15	.072	2.89	2.93	3.26	3.08
16	.065	2.61	2.64	2.94	2.78
17	.058	2.33	2.36	2.63	2.48
18	.049	1.97	1.99	2.22	2.10
19	.042	1.69	1.71	1.90	1.80
20	.035	1.40	1.42	1.59	1.50
21	.032	1.28	1.30	1.45	1.37
22	.028	1.12	1.14	1.27	1.20
23	.025	1.00	1.02	1.13	1.07
24	.022	.883	.895	1.00	.942
25	.02	.803	.813	.906	.856
26	.018	.722	.732	.815	.770
27	.016	.642	.651	.725	.685
28	.014	.562	.569	.634	.599
29	.013	.522	.529	.589	.556
30	.012	.482	.488	.544	.514
31	.01	.401	.407	.453	.428
32	.009	.361	.366	.408	.385
33	.008	.321	.325	.362	.342
34	.007	.281	.285	.317	.300
35	.005	.201	.203	.227	.214
Specific Gravity,		7.704	7.806	8.698	8.218
Weight Cubic Foot,		481.25	487.75	543.6	513.6
" " Inch,		.2787	.2823	.3146	.2972

Weight of Sheets of Wrought Iron, Steel, Copper and Brass. From Haswell.

Weight per Square Foot. Thickness by American (Brown & Sharpe's) Gauge.

No. of Gauge.	Thickness in inches.	Iron.	Steel.	Copper.	Brass.
0000	.46	18.46	18.70	20.84	19.69
000	.4096	16.44	16.66	18.56	17.53
00	.3648	14.64	14.83	16.53	15.61
0	.3249	13.04	13.21	14.72	13.90
1	.2893	11.61	11.76	13.11	12.38
2	.2576	10.34	10.48	11.67	11.03
3	.2294	9.21	9.33	10.39	9.82
4	.2043	8.20	8.31	9.26	8.74
5	.1819	7.30	7.40	8.24	7.79
6	.1620	6.50	6.59	7.34	6.93
7	.1443	5.79	5.87	6.54	6.18
8	.1285	5.16	5.22	5.82	5.50
9	.1144	4.59	4.65	5.18	4.90
10	.1019	4.09	4.14	4.62	4.36
11	.0907	3.64	3.69	4.11	3.88
12	.0808	3.24	3.29	3.66	3.46
13	.0720	2.89	2.93	3.26	3.08
14	.0641	2.57	2.61	2.90	2.74
15	.0571	2.29	2.32	2.59	2.44
16	.0508	2.04	2.07	2.30	2.18
17	.0453	1.82	1.84	2.05	1.94
18	.0403	1.62	1.64	1.83	1.73
19	.0359	1.44	1.46	1.63	1.54
20	.0320	1.28	1.30	1.45	1.37
21	.0285	1.14	1.16	1.29	1.22
22	.0253	1.02	1.03	1.15	1.08
23	.0226	.906	.918	1.02	.966
24	.0201	.807	.817	.911	.860
25	.0179	.718	.728	.811	.766
26	.0159	.640	.648	.722	.682
27	.0142	.570	.577	.643	.608
28	.0126	.507	.514	.573	.541
29	.0113	.452	.458	.510	.482
30	.0100	.402	.408	.454	.429
31	.0089	.358	.363	.404	.382
32	.0080	.319	.323	.360	.340
33	.0071	.284	.288	.321	.303
34	.0063	.253	.256	.286	.270
35	.0056	.225	.228	.254	.240

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

For Thicknesses from 1-16 in. to 2 in., and Width from 1 in. to 12¾ in.

Iron weighing 480 lbs. per cubic foot.

Thickness in Inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	12″
1/16	.208	.260	.313	.365	.417	.469	.521	.573	2.50
1/8	.417	.521	.625	.729	.833	.938	1.04	1.15	5.00
3/16	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	7.50
1/4	.833	1.04	1.25	1.46	1.67	1.88	2.08	2.29	10.00
5/16	1.04	1.30	1.56	1.82	2.08	2.34	2.60	2.86	12.50
3/8	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	15.00
7/16	1.46	1.82	2.19	2.55	2.92	3.28	3.65	4.01	17.50
1/2	1.67	2.08	2.50	2.92	3.33	3.75	4.17	4.58	20.00
9/16	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	22.50
5/8	2.08	2.60	3.13	3.65	4.17	4.69	5.21	5.73	25.00
11/16	2.29	2.86	3.44	4.01	4.58	5.16	5.73	6.30	27.50
3/4	2.50	3.13	3.75	4.38	5.00	5.63	6.25	6.88	30.00
13/16	2.71	3.39	4.06	4.74	5.42	6.09	6.77	7.45	32.50
7/8	2.92	3.65	4.38	5.10	5.83	6.56	7.29	8.02	35.00
15/16	3.13	3.91	4.69	5.47	6.25	7.03	7.81	8.59	37.50
1	3.33	4.17	5.00	5.83	6.67	7.50	8.33	9.17	40.00
1 1/16	3.54	4.43	5.31	6.20	7.08	7.97	8.85	9.74	42.50
1 1/8	3.75	4.69	5.63	6.56	7.50	8.44	9.38	10.31	45.00
1 3/16	3.96	4.95	5.94	6.93	7.92	8.91	9.90	10.89	47.50
1 1/4	4.17	5.21	6.25	7.29	8.33	9.38	10.42	11.46	50.00
1 5/16	4.37	5.47	6.56	7.66	8.75	9.84	10.94	12.03	52.50
1 3/8	4.58	5.73	6.88	8.02	9.17	10.31	11.46	12.60	55.00
1 7/16	4.79	5.99	7.19	8.39	9.58	10.78	11.98	13.18	57.50
1 1/2	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	60.00
1 9/16	5.21	6.51	7.81	9.11	10.42	11.72	13.02	14.32	62.50
1 5/8	5.42	6.77	8.13	9.48	10.83	12.19	13.54	14.90	65.00
1 11/16	5.63	7.03	8.44	9.84	11.25	12.66	14.06	15.47	67.50
1 3/4	5.83	7.29	8.75	10.21	11.67	13.13	14.58	16.04	70.00
1 13/16	6.04	7.55	9.06	10.57	12.08	13.59	15.10	16.61	72.50
1 7/8	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	75.00
1 15/16	6.46	8.07	9.69	11.30	12.92	14.53	16.15	17.76	77.50
2	6.67	8.33	10.00	11.67	13.33	15.00	16.67	18.33	80.00

WEIGHT OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	12″
1/16	.625	.677	729	.781	833	.885	.938	.990	2.50
1/8	1.25	1.35	1 46	1.56	1 67	1.77	1.88	1.98	5.00
3/16	1.88	2.03	2.19	2 34	2 50	2.66	2.81	2.97	7.50
1/4	2.50	2.71	2.92	3.13	3 33	3.54	3.75	3.96	10.00
5/16	3 13	3 39	3.65	3.91	4 17	4.43	4.69	4.95	12.50
3/8	3 75	4.06	4 38	4 69	5 00	5.31	5 63	5.94	15.00
7/16	4.38	4 74	5.10	5.47	5.83	6.20	6.56	6.93	17.50
1/2	5.00	5.42	5.83	6.25	6.67	7.08	7.50	7.92	20.00
9/16	5.63	6.09	6.56	7.03	7.50	7 97	8 44	8.91	22.50
5/8	6.25	6.77	7.29	7.81	8.33	8.85	9 38	9.90	25.00
11/16	6.88	7.45	8.02	8.59	9.17	9.74	10.31	10.89	27.50
3/4	7.50	8.13	8.75	9.38	10.00	10.63	11.25	11.88	30.00
13/16	8.13	8.80	9 48	10.16	10.83	11.51	12.19	12.86	32.50
7/8	8.75	9.48	10.21	10.94	11.67	12.40	13.13	13.85	35.00
15/16	9.38	10.16	10.94	11.72	12.50	13.28	14.06	14.84	37.50
1	10.00	10.83	11.67	12.50	13.33	14.17	15.00	15.83	40.00
1 1/16	10 63	11 51	12.40	13.28	14.17	15.05	15.94	16.82	42.50
1 1/8	11.25	12.19	13.13	14.06	15.00	15.94	16.88	17.81	45.00
1 3/16	11.88	12.86	13.85	14.84	15.83	16.82	17.81	18.80	47.50
1 1/4	12.50	13.54	14.58	15.63	16.67	17.71	18.75	19.79	50.00
1 5/16	13.13	14.22	15.31	16.41	17.50	18.59	19.69	20.78	52.50
1 3/8	13.75	14 90	16.04	17.19	18.33	19.48	20.63	21.77	55.00
1 7/16	14.38	15.57	16.77	17.97	19.17	20.36	21.56	22.76	57.50
1 1/2	15.00	16.25	17.50	18.75	20.00	21.25	22.50	23.75	60.00
1 9/16	15.63	16.93	18.23	19.53	20.83	22.14	23.44	24.74	62.50
1 5/8	16.25	17.60	18.96	20.31	21.67	23.02	24.38	25.73	65.00
1 11/16	16.88	18.28	19.69	21.09	22.50	23.91	25.31	26.72	67.50
1 3/4	17.50	18.96	20.42	21.88	23.33	24.79	26.25	27.71	70.00
1 13/16	18.13	19.64	21.15	22.66	24.17	25.68	27.19	28.70	72.50
1 7/8	18.75	20.31	21.88	23.44	25.00	26.56	28.13	29.69	75.00
1 15/16	19.38	20.99	22.60	24.22	25.83	27.45	29.06	30.68	77.50
2	20.00	21.67	23.33	25.00	26.67	28.33	30.00	31.67	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	5″	5¼″	5½″	5¾″	6″	6¼″	6½″	6¾″	12″
1/16	1.04	1.09	1.15	1.20	1.25	1.30	1.35	1.41	2.50
1/8	2.08	2.19	2.29	2.40	2.50	2.60	2.71	2.81	5.00
3/16	3.13	3.28	3.44	3.59	3.75	3.91	4.06	4.22	7.50
1/4	4.17	4.38	4.58	4.79	5.00	5.21	5.42	5.63	10.00
5/16	5.21	5.47	5.73	5.99	6.25	6.51	6.77	7.03	12.50
3/8	6.25	6.56	6.88	7.19	7.50	7.81	8.13	8.44	15.00
7/16	7.29	7.66	8.02	8.39	8.75	9.11	9.48	9.84	17.50
1/2	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	20.00
9/16	9.38	9.84	10.31	10.78	11.25	11.72	12.19	12.66	22.50
5/8	10.42	10.94	11.46	11.98	12.50	13.02	13.54	14.06	25.00
11/16	11.46	12.03	12.60	13.18	13.75	14.32	14.90	15.47	27.50
3/4	12.50	13.13	13.75	14.38	15.00	15.63	16.25	16.88	30.00
13/16	13.54	14.22	14.90	15.57	16.25	16.93	17.60	18.28	32.50
7/8	14.58	15.31	16.04	16.77	17.50	18.23	18.96	19.69	35.00
15/16	15.63	16.41	17.19	17.97	18.75	19.53	20.31	21.09	37.50
1	16.67	17.50	18.33	19.17	20.00	20.83	21.67	22.50	40.00
1 1/16	17.71	18.59	19.48	20.36	21.25	22.14	23.02	23.91	42.50
1 1/8	18.75	19.69	20.63	21.56	22.50	23.44	24.38	25.31	45.00
1 3/16	19.79	20.78	21.77	22.76	23.75	24.74	25.73	26.72	47.50
1 1/4	20.83	21.88	22.92	23.96	25.00	26.04	27.08	28.13	50.00
1 5/16	21.88	22.97	24.06	25.16	26.25	27.34	28.44	29.53	52.50
1 3/8	22.92	24.06	25.21	26.35	27.50	28.65	29.79	30.94	55.00
1 7/16	23.96	25.16	26.35	27.55	28.75	29.95	31.15	32.34	57.50
1 1/2	25.00	26.25	27.50	28.75	30.00	31.25	32.50	33.75	60.00
1 9/16	26.04	27.34	28.65	29.95	31.25	32.55	33.85	35.16	62.50
1 5/8	27.08	28.44	29.79	31.15	32.50	33.85	35.21	36.56	65.00
1 11/16	28.13	29.53	30.94	32.34	33.75	35.16	36.56	37.97	67.50
1 3/4	29.17	30.63	32.08	33.54	35.00	36.46	37.92	39.38	70.00
1 13/16	30.21	31.72	33.23	34.74	36.25	37.76	39.27	40.78	72.50
1 7/8	31.25	32.81	34.38	35.94	37.50	39.06	40.63	42.19	75.00
1 15/16	32.29	33.91	35.52	37.14	38.75	40.36	41.98	43.59	77.50
2	33.33	35.00	36.67	38.33	40.00	41.67	43.33	45.00	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	7″	7¼″	7½″	7¾″	8″	8¼″	8½″	8¾″	12″
1/16	1.46	1.51	1.56	1.61	1.67	1.72	1.77	1.82	2.50
1/8	2.92	3.02	3.13	3.23	3.33	3.44	3.54	3.65	5.00
3/16	4.38	4.53	4.69	4.84	5.00	5.16	5.31	5.47	7.50
1/4	5.83	6.04	6.25	6.46	6.67	6.88	7.08	7.29	10.00
5/16	7.29	7.55	7.81	8.07	8.33	8.59	8.85	9.11	12.50
3/8	8.75	9.06	9.38	9.69	10.00	10.31	10.63	10.94	15.00
7/16	10.21	10.57	10.94	11.30	11.67	12.03	12.40	12.76	17.50
1/2	11.67	12.08	12.50	12.92	13.33	13.75	14.17	14.58	20.00
9/16	13.13	13.59	14.06	14.53	15.00	15.47	15.94	16.41	22.50
5/8	14.58	15.10	15.63	16.15	16.67	17.19	17.71	18.23	25.00
11/16	16.04	16.61	17.19	17.76	18.33	18.91	19.48	20.05	27.50
3/4	17.50	18.13	18.75	19.38	20.00	20.63	21.25	21.88	30.00
13/16	18.96	19.64	20.31	20.99	21.67	22.34	23.02	23.70	32.50
7/8	20.42	21.15	21.88	22.60	23.33	24.06	24.79	25.52	35.00
15/16	21.88	22.66	23.44	24.22	25.00	25.78	26.56	27.34	37.50
1	23.33	24.17	25.00	25.83	26.67	27.50	28.33	29.17	40.00
1 1/16	24.79	25.68	26.56	27.45	28.33	29.22	30.10	30.99	42.50
1 1/8	26.25	27.19	28.13	29.06	30.00	30.94	31.88	32.81	45.00
1 3/16	27.71	28.70	29.69	30.68	31.67	32.66	33.65	34.64	47.50
1 1/4	29.17	30.21	31.25	32.29	33.33	34.38	35.42	36.46	50.00
1 5/16	30.62	31.72	32.81	33.91	35.00	36.09	37.19	38.28	52.50
1 3/8	32.08	33.23	34.38	35.52	36.67	37.81	38.96	40.10	55.00
1 7/16	33.54	34.74	35.94	37.14	38.33	39.53	40.73	41.93	57.50
1 1/2	35.00	36.25	37.50	38.75	40.00	41.25	42.50	43.75	60.00
1 9/16	36.46	37.76	39.06	40.36	41.67	42.97	44.27	45.57	62.50
1 5/8	37.92	39.27	40.63	41.98	43.33	44.69	46.04	47.40	65.00
1 11/16	39.38	40.78	42.19	43.59	45.00	46.41	47.81	49.22	67.50
1 3/4	40.83	42.29	43.75	45.21	46.67	48.13	49.58	51.04	70.00
1 13/16	42.29	43.80	45.31	46.82	48.33	49.84	51.35	52.86	72.50
1 7/8	43.75	45.31	46.88	48.44	50.00	51.56	53.13	54.69	75.00
1 15/16	45.21	46.82	48.44	50.05	51.67	53.28	54.90	56.51	77.50
2	46.67	48.33	50.00	51.67	53.33	55.00	56.67	58.33	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	9″	9¼″	9½″	9¾″	10″	10¼″	10½″	10¾″	12″
1/16	1.88	1.93	1.98	2.03	2.08	2.14	2.19	2.24	2.50
1/8	3.75	3.85	3.96	4.06	4.17	4.27	4.38	4.48	5.00
3/16	5.63	5.78	5.94	6.09	6.25	6.41	6.56	6.72	7.50
1/4	7.50	7.71	7.92	8.13	8.33	8.54	8.75	8.96	10.00
5/16	9.38	9.64	9.90	10.16	10.42	10.68	10.94	11.20	12.50
3/8	11.25	11.56	11.88	12.19	12.50	12.81	13.13	13.44	15.00
7/16	13.13	13.49	13.85	14.22	14.58	14.95	15.31	15.68	17.50
1/2	15.00	15.42	15.83	16.25	16.67	17.08	17.50	17.92	20.00
9/16	16.88	17.34	17.81	18.28	18.75	19.22	19.69	20.16	22.50
5/8	18.75	19.27	19.79	20.31	20.83	21.35	21.88	22.40	25.00
11/16	20.63	21.20	21.77	22.34	22.92	23.49	24.06	24.64	27.50
3/4	22.50	23.13	23.75	24.38	25.00	25.62	26.25	26.88	30.00
13/16	24.38	25.05	25.73	26.41	27.08	27.76	28.44	29.11	32.50
7/8	26.25	26.98	27.71	28.44	29.17	29.90	30.63	31.35	35.00
15/16	28.13	28.91	29.69	30.47	31.25	32.03	32.81	33.59	37.50
1	30.00	30.83	31.67	32.50	33.33	34.17	35.00	35.83	40.00
1 1/16	31.88	32.76	33.65	34.53	35.42	36.30	37.19	38.07	42.50
1 1/8	33.75	34.69	35.63	36.56	37.50	38.44	39.38	40.31	45.00
1 3/16	35.63	36.61	37.60	38.59	39.58	40.57	41.56	42.55	47.50
1 1/4	37.50	38.54	39.58	40.63	41.67	42.71	43.75	44.79	50.00
1 5/16	39.38	40.47	41.56	42.66	43.75	44.84	45.94	47.03	52.50
1 3/8	41.25	42.40	43.54	44.69	45.83	46.98	48.13	49.27	55.00
1 7/16	43.13	44.32	45.52	46.72	47.92	49.11	50.31	51.51	57.50
1 1/2	45.00	46.25	47.50	48.75	50.00	51.25	52.50	53.75	60.00
1 9/16	46.88	48.18	49.48	50.78	52.08	53.39	54.69	55.99	62.50
1 5/8	48.75	50.10	51.46	52.81	54.17	55.52	56.88	58.23	65.00
1 11/16	50.63	52.03	53.44	54.84	56.25	57.66	59.06	60.47	67.50
1 3/4	52.50	53.96	55.42	56.88	58.33	59.79	61.25	62.71	70.00
1 13/16	54.38	55.89	57.40	58.91	60.42	61.93	63.44	64.95	72.50
1 7/8	56.25	57.81	59.38	60.94	62.50	64.06	65.63	67.19	75.00
1 15/16	58.13	59.74	61.35	62.97	64.58	66.20	67.81	69.43	77.50
2	60.00	61.67	63.33	65.00	66.67	68.33	70.00	71.67	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in Inches.	11″	11¼″	11½″	11¾″	12″	12¼″	12½″	12¾″
1/16	2.29	2.34	2.40	2.45	2.50	2.55	2.60	2.66
1/8	4.58	4.69	4.79	4.90	5.00	5.10	5.21	5.31
3/16	6.88	7.03	7.19	7.34	7.50	7.66	7.81	7.97
1/4	9.17	9.38	9.58	9.79	10.00	10.21	10.42	10.63
5/16	11.46	11.72	11.98	12.24	12.50	12.76	13.02	13.28
3/8	13.75	14.06	14.38	14.69	15.00	15.31	15.63	15.94
7/16	16.04	16.41	16.77	17.14	17.50	17.86	18.23	18.59
1/2	18.33	18.75	19.17	19.58	20.00	20.42	20.83	21.25
9/16	20 63	21.09	21.56	22.03	22.50	22.97	23.44	23.91
5/8	22.92	23.44	23.96	24.48	25.00	25.52	26.04	26.56
11/16	25.21	25.78	26.35	26.93	27.50	28.07	28.65	29.22
3/4	27.50	28.13	28.75	29.38	30.00	30.63	31.25	31.88
13/16	29 79	30.47	31.15	31.82	32.50	33.18	33.85	34.53
7/8	32.08	32.81	33.54	34.27	35.00	35.73	36.46	37.19
15/16	34.38	35.16	35.94	36.72	37.50	38.28	39.06	39.84
1	36.67	37.50	38.33	39.17	40.00	40.83	41 67	42.50
1 1/16	38.96	39.84	40.73	41.61	42.50	43.39	44.27	45.16
1 1/8	41.25	42.19	43.13	44.06	45.00	45.94	46.88	47.81
1 3/16	43.54	44.53	45.52	46.51	47.50	48.49	49.48	50.47
1 1/4	45.83	46.88	47.92	48.96	50.00	51.04	52.08	53.13
1 5/16	48.13	49.22	50.31	51.41	52.50	53.59	54.69	55.78
1 3/8	50.42	51.56	52.71	53.85	55.00	56.15	57.29	58.44
1 7/16	52.71	53.91	55.10	56.30	57.50	58.70	59.90	61.09
1 1/2	55.00	56.25	57.50	58.75	60.00	61.25	62.50	63.75
1 9/16	57.29	58.59	59.90	61.20	62.50	63.80	65.10	66.41
1 5/8	59.58	60.94	62.29	63.65	65.00	66.35	67.71	69.06
1 11/16	61.88	63.28	64.69	66.09	67.50	68.91	70.31	71.72
1 3/4	64.17	65.63	67.08	68.54	70.00	71.46	72.92	74.38
1 13/16	66.46	67.97	69.48	70.99	72.50	74.01	75.52	77.03
1 7/8	68.75	70.31	71 88	73.44	75.00	76.56	78.13	79.69
1 15/16	71.04	72.66	74 27	75.89	77.50	79.11	80.73	82.34
2	73.33	75.00	76.67	78.33	80.00	81.67	83.33	85.00

The weights for 12″ width are repeated on each page to facilitate making the additions necessary to obtain the weights of plates wider than 12″. Thus, to find the weight of 15¼″ × ⅞″, add the weights to be found in the same line for 3¼ × ⅞ and 12 × ⅞ = 9.48 + 35.00 = 44.48 lbs.

Weight of Rivets, and Round Headed Bolts Without Nuts, Per 100.

Length from under head. One cubic foot weighing 480 lbs.

Length Inches	⅜″ Dia.	½″ Dia.	⅝″ Dia.	¾″ Dia.	⅞″ Dia.	1″ Dia.	1⅛″ Dia.	1¼″ Dia.
1¼	5.4	12.6	21.5	28.7	43.1	65.3	91.5	123.
1½	6.2	13.9	23.7	31 8	47.3	70.7	98.4	133.
1¾	6.9	15.3	25.8	34.9	51.4	76.2	105.	142.
2	7.7	16.6	27.9	37.9	55.6	81.6	112.	150.
2¼	8.5	18.0	30.0	41.0	59.8	87.1	119.	159.
2½	9.2	19.4	32.2	44.1	63.0	92.5	126.	167.
2¾	10.0	20.7	34.3	47.1	68.1	98.0	133.	176.
3	10.8	22.1	36.4	50.2	72.3	103.	140.	184
3¼	11.5	23.5	38.6	53 3	76 5	109	147.	193.
3½	12.3	24.8	40 7	56 4	80 7	114.	154.	201.
3¾	13.1	26.2	42.8	59.4	84.8	120.	161.	210.
4	13.8	27.5	45.0	62.5	89 0	125.	167.	218.
4¼	14.6	28.9	47.1	65.6	93.2	131.	174	227.
4½	15.4	30.3	49.2	68.6	97 4	136.	181.	236.
4¾	16.2	31.6	51.4	71.7	102.	142.	188.	244.
5	16.9	33.0	53.5	74.8	106.	147.	195.	253.
5¼	17.7	34.4	55.6	77.8	110.	153.	202.	261.
5½	18.4	35.7	57.7	80.9	114.	158.	209.	270.
5¾	19.2	37.1	59.9	84.0	118.	163.	216.	278.
6	20.0	38.5	62.0	87.0	122.	169.	223.	287.
6½	21.5	41.2	66.3	93.2	131.	180.	236.	304.
7	23.0	43.9	70.5	99 3	139.	191.	250	321.
7½	24.6	46.6	74.8	106.	147.	202.	264.	338.
8	26.1	49.4	79.0	112.	156.	213.	278.	355.
8½	27.6	52.1	83.3	118.	164.	223.	292	372.
9	29.2	54.8	87.6	124.	173.	234.	306.	389.
9½	30.7	57.6	91.8	130.	181	245.	319.	406.
10	32.2	60.3	96.1	136.	189.	256.	333.	423.
10½	33.8	63.0	101.	142.	198.	267.	347.	440.
11	35.3	65.7	105.	148.	206.	278.	361.	457.
11½	36.8	68.5	109.	155.	214.	289.	375.	474.
12	38.4	71.2	113.	161.	223.	300.	388.	491.
Heads.	1.8	5.7	10.9	13.4	22.2	38.0	57.0	82.0

WEIGHT OF CAST IRON PER LINEAL FOOT.—Example: What is weight of a cast iron plate 2″ x 14″ x one foot long? Ans.—The thickness multiplied by width equals 28″ of sectional area.

In the sixth column, we find that 87½ lbs. is the weight of a piece with a sectional area of 28″ and one foot long.

Area Inches.	Lbs.	Area Inches.	Lbs.	Area Inches.	Lbs.	Area Inches.	Lbs.	Area Inches.	Lbs.
1/16	.20	6	18.75	21½	67.19	43	134.38	69	215.63
⅛	.39	6¼	19.53	22	68.75	43½	135.94	70	218.75
3/16	.59	6½	20.31	22½	70.31	44	137.5	71	221.88
¼	.78	6¾	21.09	23	71.88	44½	139.06	72	225.0
5/16	.98	7	21.88	23½	73.44	45	140.63	73	228.13
⅜	1.17	7¼	22.66	24	75.00	45½	142.19	74	231.25
7/16	1.37	7½	23.44	24½	76.56	46	143.75	75	234.38
½	1.56	7¾	24.22	25	78.13	46½	145.31	76	237.5
9/16	1.76	8	25.00	25½	79.69	47	146.87	77	240.63
⅝	1.95	8¼	25.78	26	81.25	47½	148.44	78	243.75
11/16	2.15	8½	26.56	26½	82.81	48	150.00	79	249.87
¾	2.34	8¾	27.34	27	84.38	48½	151.56	80	250.00
13/16	2.54	9	28.13	27½	85.94	49	153.12	81	253.12
⅞	2.73	9¼	28.91	28	87.5	49½	154.69	82	256.25
15/16	2.93	9½	29.69	28½	89.06	50	156.25	83	259.38
1	3.125	9¾	30.47	29	90.63	50½	157.81	84	262.5
1⅛	3.51	10	31.25	29½	92.19	51	159.38	85	265.63
1¼	3.91	10¼	32.03	30	93.75	51½	160.94	86	268.75
1⅜	4.30	10½	32.81	30½	95.31	52	162.5	87	271.88
1½	4.69	10¾	33.59	31	96.87	52½	164.06	88	275.00
1⅝	5.08	11	34.38	31½	98.44	53	165.63	89	278.13
1¾	5.47	11¼	35.16	32	100.00	53½	167.19	90	281.25
1⅞	5.86	11½	35.94	32½	101.56	54	168.75	91	284.38
[illegible]	6.25	11¾	36.72	33	103.12	54½	170.31	92	287.5
2⅛	6.64	12	37.5	33½	104.69	55	171.88	93	290.66
2¼	7.03	12½	39.06	34	106.25	55½	173.44	94	293.75
2⅜	7.42	13	40.63	34½	107.81	56	175.00	95	296.87
2½	7.81	13½	42.19	35	109.38	56½	176.56	96	300.00
2⅝	8.20	14	43.75	35½	110.94	57	178.13	97	303.13
2¾	8.59	14½	45.31	36	112.5	57½	179.69	98	306.25
2⅞	8.98	15	46.87	36½	114.06	58	181.25	99	309.38
3	9.38	15½	48.44	37	115.63	58½	182.81	100	312.5
3¼	10.16	16	50.00	37½	117.19	59	184.38	101	315.63
3½	10.94	16½	51.56	38	118.75	59½	185.94	102	318.75
3¾	11.72	17	53.12	38½	120.31	60	187.5	103	322.88
4	12.5	17½	54.69	39	121.88	61	190.63	104	325.00
4¼	13.28	18	56.25	39½	123.44	62	193.75	105	328.13
4½	14.06	18½	57.81	40	125.00	63	196.87	106	331.25
4¾	14.84	19	59.38	40½	126.56	64	200.00	107	334.38
5	15.63	19½	60.94	41	128.13	65	203.125	108	337.5
5¼	16.41	20	62.5	41½	129.69	66	206.25	109	340.63
5½	17.19	20½	64.06	42	131.25	6	209.38	110	343.75
								111	346.87
5¾	17.97	21	65.63	42½	132.81	68	212.5	112	350.00

LINEAR EXPANSION OF SUBSTANCES BY HEAT.

To find the increase in the length of a bar of any material due to an increase of temperature, multiply the number of degrees of increase of temperature by the coefficient for 100 degrees and by the length of the bar, and divide by 100.

Name of Substance.	Coefficient for 100° Fahrenheit.	Coefficient for 180° Fahrenheit, or 100° Centigrade.
Baywood, (in the direction of the grain, dry,)	.00026 TO .00031	.00046 TO 00057
Brass, (cast,)	.00104	.00188
" (wire,)	.00107	.00193
Brick, (fire,)	.0003	.0005
Cement, (Roman,)	.0008	.0014
Copper,	.0009	.0017
Deal, (in the direction of the grain, dry,)	.00024	.00044
Glass, (English flint,)	.00045	.00081
" (French white lead,)	.00048	.00087
Gold,	.0008	.0015
Granite, (average,)	.00047	.00085
Iron, (cast,)	.0006	.0011
" (soft forged,)	.0007	.0012
" (wire,)	.0008	.0014
Lead,	.0016	.0029
Marble, (Carrara,)	.00036 TO .0006	.00065 TO .0011
Mercury,	.0033	.0060
Platinum,	.0005	.0009
Sandstone,	.0005 TO .0007	.0009 TO .0012
Silver,	.0011	.002
Slate, (Wales,)	.0006	.001
Water, (varies considerably with the temperature,)	.0086	.0155

Weight of Bolts per 100, Including Nuts.

Length.	DIAMETER.								
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
1½	4.	7.	10.50	15.20	22.50	39.50	......	......	....
1¾	4.35	7.50	11.25	16.30	23.82	41.62	......	......	....
2	4.75	8.	12.	17.40	25.15	43.75	69.	....	....
2¼	5.15	8.50	12.75	18.50	26.47	45.88	72.	....	....
2½	5.50	9.	13.50	19.60	27.80	48.	75.	116.50	..
2¾	5.75	9.50	14.25	20.70	29.12	50.12	78.	121.75	..
3	6.25	10.	15.	21.80	30.45	52.25	81.	126.	....
3½	7.	11.	16.50	24.	33.10	56.50	87.	134.25	..
4	7.75	12.	18.	26.20	35.75	60 75	93.10	142.50	207
4½	8.60	13.	19.50	28.40	38.40	65.	99.05	151.	218
5	9.25	14.	21.	30.60	41.05	69.25	105.20	159.55	229
5½	10.	15.	22.50	32.80	43.70	73.50	111.25	168.	240
6	10.75	16.	24.	35.	46.35	77.75	117.30	176.60	251
6½	......	....	25.50	37.20	49.	82.	123.35	185.	262
7	....	....	27.	39.40	51.65	86.25	129.40	193.65	273
7½	....	....	28.50	41.60	54.30	90.50	135.	202.	284
8	....	....	30.	43.80	59.60	94.75	141.50	210.70	295
9	......	....	...	46.	64.90	103.25	153.60	227.75	317
10	......	....	.....	48.20	70.20	111.75	165 70	244.80	339
11	......	....	.....	50.40	75.50	120.25	177.80	261.85	360
12	......	....	.....	52.60	80 80	128.75	189.90	278.90	382
13	......	....	.....	....	86.10	137 25	202	295 95	404
14	......	....	.....	....	91.40	145.75	214.10	313.	426
15	......	....	.....	....	96 70	154 25	226.20	330 05	448
16	.....	.....	....	....	102.	162.75	238.30	347.10	470
17	.....	.....	....	....	107.30	171.	250.40	364.15	492
18	.....	....	....	....	112.60	179.50	262.60	381 20	514
19	.....	.....	....	......	117.90	188.	274.70	398.25	536
20	....	....	....	.....	123.20	206 50	286.80	415.80	558

TENSILE STRENGTH OF COMMON WOODS.

The strongest wood which grows within the confines of the United States is that known as "nutmeg" hickory, which grows in the valley of the lower Arkansas river. The most elastic is tamarack. The wood with the least elasticity and lowest specific gravity is the Ficus aurea. The wood having the highest specific gravity is the blue wood of Texas and Mexico.

The heaviest of foreign woods are the pomegranate and the lignum vitæ; the lightest is cork, which, however, is a bark, not solid wood. The tensile strength of the best known woods is set forth in the following schedule:

WOOD.	POUNDS.	WOOD.	POUNDS.
Ash	14,000	Larch	9,500
Beech	11,500	Poplar	7,000
Cedar	11,400	Spruce	10,290
Chestnut	10.500	Teak	14,000
Cypress	6,000	Walnut	7,800
Elm	13,400	Lance	23,000
Fir	12.000	Locust	20,500
Maple	10,500	Mahogany	21.000
White Oak	11.500	Willow	13,000
Pear	9,800	Lignum Vitæ	11,800
Pitch Pine	12,000		

Four hundred and thirteen different species of trees grow in the various states and territories, and of this number 16, when perfectly seasonable, will sink in water.

TEMPERING STEEL PUNCHES.

Heat your steel to cherry-red, dress out the punch, cut off the point the size of a horseshoe nail, then heat to a cherry-red, immerse it a half inch perpendicularly in the water, then take it out and stand it up perpendicular, clean the end with a piece of grinding stone. When you see the first blue pass over the point, dip it in the water the same depth as before. Clean it again with the stone, and on the appearance of the blue again, cool it off. The second blue is to make the punch tough. The reason for keeping the punch perpendicular is to allow the atmosphere and the water to cool all sides equally, and to have it cool straight and true.

HOW TO MAKE TRACING PAPER.

Take some good thin printing paper, and brush it over on one side with a solution consisting of one part, by measure, of castor oil in two parts of meth. spirit; blot off and hang up to dry. You can trace by pencil or ink on this. I have tried it and done it.

IN THE SHOP—TURNING A BALL.

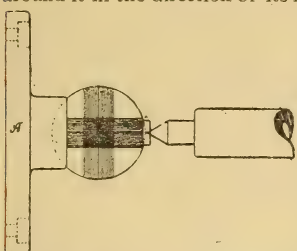
To make a ball as nearly perfect as a billiard ball is made, is not a piece of work that often falls to the lot of the machinist or pattern-maker ; but occasionally arises the necessity for such work.

In pumping where chips, sawdust, or dust is very liable to lodge on the seat under the valve, ball valves are sometimes used, because their rolling motion has a tendency to remove the obstruction, and let the valve seat fairly again. Some of the old-style locomotive pumps had ball valves; and, in tannery work, when small pieces of bark are liable to be in the liquid, ball valves can be used to advantage.

I have some such valves, four or five inches in diameter, for tanner's use. They were of brass, cast hollow, with the core holes in the shell plugged.

I have seen some costly machines which were made for the purpose of turning balls; but I have never seen any better work done by them than can be done in a common lathe.

To make the pattern of a ball, first turn the piece on centers, using the calipers to get it approximately near the shape, and then cut off the centers. Next make a chuck-block of hardwood, A, as shown in the cut, Fig. 1. Make a cup in the block to receive a small section of the ball, as also indicated. A blunt, wood center is sometimes used instead of the steel center with a concave piece of copper, as represented in cut. Either way will do for making the pattern. Put the work in the chuck so as to take the first cut around it in the direction of its former centers, or axis.



Cut lightly, and do not try to make a wide space—let it be only a narrow ribbon or turning—but get it round in the direction of present revolution ; then change the chuck so as to make another ribbon at right angles to the first, the first tool marks being the guide for the depth of the second cutting. Next change the work so as to get a ribbon between the other cuts, and continuing this process of changing and turning over the whole surface, thus making the axis of the pattern of equal length in all directions, and then the pattern will be round—it will be a ball At first it might seem as if some laying off were needed to get the "ribbons,"

as I have called them, at right angles to each other, but there is no need of that; by the eye is enough.

When the machinist comes to finish up the casting, he can bolt the chuck-block to his face plate, and use his steel center and a concave piece of copper as represented in the cut. He will have to use a hand tool, or a scraper, after getting under the scale.

If the ball becomes too small for the cup in the block, it is an easy matter to make a new fit by cutting deeper into the chuck-block.

THE ACTION OF SEA-WATER ON CAST-IRON PILES.

Indiana Engineering notes the results of some observations made by the chief engineer of the B. B. and C. I. Railway on the cast-iron piles forming the piers of the South Bassien bridge. The piles were put down in 1862. Two were found almost as fresh in appearance as when sunk, and showed no corrosions in specimens cut from the metal. The deepest corrosion found on any pile was $\frac{3}{32}$ inch; and this corrosion was the greatest near low-water mark. The pile bolts were all in excellent condition. All of these piles have been exposed to the action of sea-water for about twenty-five years, and the examination was made to set aside a current suspicion that they were deteriorating under the action of the water.

JAPANESE WATER PIPES.

The water supply of Tokio, Japan, is by the wooden water pipe system, which has been in existence over two hundred years, furnishing at present a daily supply of from twenty-five to thirty million gallons. There are several types of water pipes in use, the principal class being built up with plank, square, and secured together by frames surrounding them at close intervals. The pipes, less than six inch, consist of bored logs, and somewhat larger ones are made by placing a cap on the top of a log in which a very large groove has been cut. All the connections are made by chamfered joints, and cracks are calked with an inner fibrous bark. Square boxes are used in various places to regulate the uniformity of the flow of the water, which is rather rapid, for the purpose of preventing aquatic growth. The water is not delivered to the houses, but into reservoirs on the sides of the streets, nearly 15,000 in number.

THE HEATING POWER OF FUEL.

The heating power of fuel is ascertained by the foll wing process, which consists in burning one gramme of the c l or fuel in a small platinum crucible, supported on the bow pf a tobacco pipe, and covered by an inverted glass test tube, through which is passed a stream of oxygen, while the whole is placed under water in a glass vessel. The oxygen i fed into the test tube by a movable copper tube, which may be pushed into the test tube so as to come immediately over the crucible. The coals burn away in a few minutes with very intense heat, and the hot gases escape through the water, the bubbles being broken up by passing through sheets of wire gauze which stretch between the test tube and the walls of the vessel containing the water in which it is placed. The temperature of the water is taken before and after the experiment, and, from the figures thus obtained, the heating power of the coal is calculated.

HOW STEEL RULES ARE MADE.

There are few branches of the engineering trades that require the exactness and precision requisite in the manufacture of steel rules, standards, and measuring instruments.

Accuracy and reliability are the two absolute essentials. In the general practice the steel blades, after being prepared by being ground, glazed, and tempered, are coated by an acid-resisting varnish, specially made to suit the requirements of the trade, for upon this depends, in a great measure, the clearness of the divisions when etched. The varnish being dry, the blades are placed upon the table of a pentagraph, which might well be termed a copying machine, as its work is to transfer to the steel blades, in a diminished size, any marks, letters, or figures that may be traced ftom the copy. The latter is a plate of thin zinc, or any suitable metal, usually four times larger than the rules to be made, the divisions, figures, and letters all being made four times larger than they are required to be when engraved upon the steel blades; the object of this increased size being to diminish any imperfection that may exist upon the copy. There is a tracer connected by a system of steel bands and pulleys to the table so constructed as to move in two opposite directions at right angles to each other. Above the table are fixed two rows of holders, each having a diamond point; these holders are raised and lowered at the will of the operator by a treadle, so that both divisions, figures, and letters are traced from the copy

and transferred in a diminished proportion, to the steel blades. The diamond points being required only to cut through the varnish, the blades are taken from the machine and etched, the acid burning away the steel wherever the diamond point has been traced.

A WATER CURTAIN.

A fire in a large spice mill adjoining the Chicago Public Library gave the first opportunity for testing the water curtain. the apparatus for producing which forms a part of the building. Tubes are arranged on the outside of the building on the top through which water can be turned, and the arrangement proved thoroughly satisfactory. Streams of water ponred out of the tubes, covering the walls, and owing to the temperature they were coated with ice in a few minutes. It looked like a closely woven curtain through which the flames and even the heat could not penetrate. Not a pane of glass was injured and the paint of the window frames did not crack.

CHEMICAL OR PHYSICAL TESTS FOR STEEL.

Captain Jones, of the Edgar Thomson Steel Works, Pittsburg, was in Edinburgh at the meeting of the Union and Steel Institute, and, when invited to speak, said he could not let what Mr. Clark had said about the practice of punching steel plates in America pass without comment. Punching steel plates was a relic of barbarism, and there was an appropriateness about the president's suggestion, to "punch a man who punched a plate." As to the relative cost of punching and drilling, he had long since made up his mind about that, for many years ago, in constructing a roof, he had drilled all the holes and found it cheaper than punching. With regard to the use of steel in America, they found boiler-makers, bridge-makers and many others using it largely. They had started with physical tests, not chemical analysis, but they had come to the conclusion that physical tests could be met, and yet the metal not be what it should be. The test for boiler plates at the Edgar Thomson Works was higher than that demanded for the boiler plates of the United States cruisers, the limit for phosphorus being .035, and manganese, .350 per cent. He had seen steel made in America, where the heat had been blown for eight minutes, the manganese being put in cold, and he was of opinion that the reaction had not taken place up to the time of speaking. With regard

to steel for bridge construction, he considered that not more than .065 per cent. of phosphorus should be present, and the manganese should be kept low, as that was the great oxidizing agent. He would like to see these conditions enforced by law. In conclusion he wished to impress on his hearers the necessity for judging steel by chemical tests first, and letting the physical tests be subsidiary to them.

SUGGESTIONS TO STEEL WORKERS.

Messrs. Miller, Metcalf & Parkin, of Pittsburgh, have issued a pamphlet on this subject. They draw attention to the following points:

Annealing—There is nothing gained by heating a piece of steel hotter than a bright cherry-red heat; on the contrary, a higher heat may render the steel harder on cooling than would be the case with the heat just mentioned. Besides this, the scale formed would be granular, and would spoil the tools to be used in working the metal, and the metal itself would change its structure, and become brittle.

Steel should never be left in a hot furnace over night, as the metal becomes too hot, and is spoilt for after treatment.

Forge Steel—The difficulty experienced in the forge fire is usually due more to uneven heat than to a high temperature. If heated too rapidly, the outside of the bar becomes soft, while the inside is still hard, and at too low a temperature for treatment.

In some cases a high heat is more desirable to save heavy labor; but in every case where a fine steel is to be used for cutting purposes, it must be borne in mind that every heavy forging refines the bars as they slowly cool, and, if the smith heats such refined bars until they are soft, he raises the grain, makes them coarse, and he cannot get them fine again, unless he has a very heavy steam hammer at command, and knows how to use it well.

When the steel is hot through, it should be taken from the fire immediately, and forged as quickly as possible. "Soaking" in the fire causes steel to become "dry" and brittle, and does it very great injury.

Temper—The word "temper," as used by the steelmaker, indicates the amount of carbon in steel; thus, steel of high temper, is steel containing much carbon; steel of low temper, is steel containing little carbon; steel of medium temper is steel containing carbon between these limits. Between the highest and the lowest, there are some twenty divisions, each representing a definite percentage of carbon.

The act of tempering steel is the act of giving to a piece

of steel, after it has been shaped, the hardness necessary for the work it has to do. This is done by first hardening the piece — generally a good deal harder than is necessary — and then toughening it by slow heating and gradual softening until it is just right for work.

A piece of steel, properly tempered, should always be finer in grain than the bar from which it is made. If it is necessary, in order to make the piece as hard as is required, to heat it so hot that after being hardened it will be as coarse or coarser in grain than the bar, then the steel itself is of too low a temper for the desired purpose. In a case of this kind, the steelmaker should at once be notified of the fact, and could immediately correct the trouble by furnishing higher steel.

Heating—There are three distinct stages or times of heating:

First, for forging; second, for hardening; third, for tempering.

The first requisite for a good heat for forging is a clean fire, and plenty of fuel, so that jets of hot air will not strike the corners of the piece; next, the fire should be regular, and give a good uniform heat to the whole part to be forged. It should be keen enough to heat the piece as rapidly as possible, and allow it to be thoroughly heated through, without being so fierce as to overheat the corners. Steel should not be left in fire any longer than is necessary to heat it through; and, on the other hand, it is necessary that it should be hot through to prevent surface cracks, which are caused by the reduced cohesion of the overheated parts which overlie the colder central portion of an irregularly heated piece.

By observing these precautions, a piece of steel may always be heated safely up to even a bright yellow heat when there is much forging to be done on it, and at this heat it will weld well. The best and most economical of welding fluxes is clean, crude borax, which should be first throughly melted, and then ground to fine powder. Borax, prepared in this way, will not froth on the steel, and one-half of the usual quantity will do the work as well as the whole quantity unmelted.

After the steel is properly heated, it should be forged to shape as quickly as possible; and, just as the red heat is leaving the parts intended for cutting edges, these parts should be refined by rapid, light blows, continued until the red disappears.

For the second stage of heating, for hardening, great care should be used, first, to protect the cutting edges and

working parts from heating more rapidly than the body of the piece; next, that the whole part to be hardened be heated uniformly through without any part becoming visibly hotter than the other. A uniform heat, as low as will give the required hardness, is the best for hardening. For every variation of heat which is great enough to be seen, there will result a variation in grain, which may be seen by breaking the piece; and for every variation in temperature, a crack is likely to be produced. Many a costly tool is ruined by inattention to this point. The effect of too high a heat is to open the grain — to make the steel coarse. The effect of an irregular heat is to cause irregular grain, irregular strains and cracks.

As soon as the piece is properly heated for hardening, it should be promptly and thoroughly quenched in plenty of the cooling medium — water, brine, or oil, as the case may be. An abundance of the cooling bath, to do the work quickly and uniformly all over, is very necessary to good and safe work; and to harden a large piece safely, a running stream should be used. Much uneven hardening is caused by the use of too small baths.

For the third stage of heating, to temper, the first important requisite is again uniformity; the next is time. The more slowly a piece is brought down to its temper, the better and safer is the operation. When expensive tools, such as taps, rose cutters, etc., are to be made, it is a wise precaution, and one easily taken, to try small pieces of the steel at different temperatures, so as to find out how low a heat will give the necessary hardness. The lowest heat is the best for any steel; the test costs nothing, takes very little time, and very often saves considerable loss.

A NEW BREATHING APPARATUS.

A new breathing apparatus has been invented by an Austrian. It is for use as a rescue apparatus for coal mines It consists of an India rubber cloth receptacle made in the form of a collar which closely surrounds the wearer's neck, serving as a breathing bag, and at the same time to hold a store of quickline for absorbing the carbonic acid and water vapor. A mask tightly enclosing the face is also employed, and oxygen can be breathed from an accompanying container, so that a man wearing these appliances can remain in a locality filled with irrespirable gases. It will be precious for firemen descending in cellars filled with carbonic acid gas, or for well-diggers having to fight sewer gas.

LIQUID HYDROGEN.

In the spring of 1898, Prof. Dewar, of the British Royal Institution, succeeded in liquefying the most volatile of all gases, hydrogen. Liquid hydrogen is colorless, transparent, and of only one-fourteenth of the density of water. It is so cold that it freezes and solidifies air and oxygen instantly. In a closed tube brought in contact with it, the air freezes into a small lump, leaving the tube a vacuum.

LARGEST BELT.

It is said that the largest belt ever made was turned out by a Canadian concern. It measures 3,529 feet long and is of rubber, its weight being 9 tons. It is made for the grain elevator of the Intercolonial Railway at St. Johns, N. B.

WATCH AND LEARN.

This is an excellent motto for every young man to adopt, and, by a close observance of it, it will prove of great value, even after he becomes grown up and starts out in business for himself. There is no surer way of gaining knowledge than by a careful and understanding watchfulness of others in the same line of business as yourself. As an apprentice, you cannot expect to know everything, and the best way to gain information from others is to show a willingness to learn; then they will take an interest in teaching. But if, as is too often the case, a young man, after he has been a few months in a place, pretends to know as much, and sometimes more, than those much older and more experienced than himself, he will not get much information from his fellow workmen; neither will he retain their good will for any length of time, and may expect to have all manner of practical jokes played upon him. As a journeyman, if you are intelligent, you will very often have occasion to believe that you do not know it all, and, in fact, the longer you live and the more you learn, the more you will find that there is to be learned. The egotistical and loud man is seldom a perfect man, and is generally very far from being as near perfection as he would have others think him. The person who, on a first acquaintance, is anxious to tell you what he knows, and is very free in giving advice and information without the asking, generally exhausts the supply before very long. He who is willing to listen is generally the one whose source of information is broader and of a more durable, valuable and substantial kind An example may prove the idea to be conveyed more

clearly. An employer was in want of a good, practical and experienced man for a certain class of work. A young man applied for the position, who was very certain that he "knew all about the machine," and he was engaged. It was not long before every man in the shop knew all that he did, and one very valuable thing that he did not, and that was that he did not know all that he pretended to. His manner and braggadacio very soon got most of the men down on him. They were not disappointed. The new machine arrived, and was set up ready for operation. The young man was given a job to be worked off, and began operations with that self-conscious air of superiority that is generally apparent in characters of this description. One whole day he worked at the job, and it was not then in a condition to be run. Not only that, but he had shown to the men, who, of course, were secretly watching him, that he knew practically nothing of the machine. Then he began to lay the blame for the trouble upon others, and asked assistance and "points" from some of the other workmen. This of course he did not get, and finally another man was put on the job, and he was discharged amid the taunts and ridicule of the others. If the young man had shown good sense when he first came into the shop; not been quite so free to tell all he knew, and had shown a willingness to learn, there was not a man in the place that would not have gladly assisted him, and he might have remained in a good position. It sometimes pays to be ignorant, at least a little modesty is a good thing to take with you on going to a new place. If you know more than you pretend, it will soon be found out, and you will be the gainer; but, if you fail to make good your pretensions, not only your employer but all your fellow workmen will be "down on you," and things will be correspondingly unpleasant.

DEOXIDIZED COPPER.

The advantages to be obtained by the use of copper as nearly chemically pure as possible, are generally admitted, whether the metal be used as copper or in the form of brass, bronze, or the many other alloys into which it enters. The Deoxidized Metal Company, of Bridgeport, Conn., claims that the desired result is secured by the process which is used in its works. The castings of brass, bronze, etc., made under this process, are most excellent, while the sheet copper and brass, and the wire made, when submitted to careful tests, show an unusually high degree of strength, copper wire having been tested up to 70,000 lbs. per square inch, tensile

strength. The deoxidized metal also possesses the property of great resistance to acids, so that it can be used for many purposes where ordinary metal is soon destroyed by the chemical action. Journal-bearings made from this metal have also been tested with very favorable results, while for bells it is claimed that the tone and quality is much superior to ordinary brass.

MAKING JAPANNED LEATHER.

Japanned leather, generally called patent leather, was first made in America. A smooth, glazed surface is first given to calfskin in France. The leather is curried expressly for this purpose, and parcicular care is taken to keep as free as possible from grease; the skins are then tacked on frames and coated with a composition of linseed oil and umber—in the proportion of 18 gallons of oil to 5 of umber—boiled until nearly solid, and then mixed with spirits of turpentine to its proper consistency. Lampblack is also added when the composition is applied, in order to give color and body. From three to four coats are necessary to form a substance to receive the varnish. They are laid on with a knife or scraper. To render the goods soft and pliant each coat must be very light and thoroughly dried after each application.

A thin coat is afterward applied of the same composition, of proper consistency, to be put on with a brush, and with sufficient lampblack boiled in it to make a perfect black. When thoroughly dry it is cut down with a scraper having turned edges. It is then ready to varnish. The principal varnish used is made of linseed oil and Russian blue boiled to the thickness of printers' ink. It is reduced with spirits of turpentine to a suitable consistency to work with a brush and then applied in two or three separate coats, which are scraped and pumiced until the leather is perfectly filled and smooth.

The finishing coat is put on with special care in a room kept closed and with the floor wet to prevent dust. The frames are then run into an oven heated to about 175 degress. In preparing this kind of leather the manufacturer must give the skin as high a heat as it can bear, in order to dry the composition on the surface as rapidly as possible without absorption, and cautiously, so as not to injure the fibre of the leather. It is well nigh impossible to guarantee the permanency of patent leather, no matter how expensive or how careful be the preparation, for it has a sad trick of cracking without any justifiable provocation.

HOW TO LACQUER BRASS.

It is strange that not one druggist out of ten knows how to compound and put up a first-class lacquer, but depends entirely on the manufacturer, who, owing to the general lack of knowledge regarding the matter, often imposes upon their customers, sending a vastly inferior article. Again, not one customer in ten knows how to apply lacquer, and the druggist is blamed, when the user's ignorance is the cause of failure. Let both the dealer and the consumer keep the following constantly in mind when selling or using lacquer:

Remove the last vestige of oil or grease from the goods to be lacquered, and do not touch the work with the fingers. A pair of spring tongs or a taper stick in some of the holes is the best way of holding.

Heat the work sufficiently hot to cause the brush to smoke when applied, but do not make hot enough to harm the lacquer.

Fasten a small wire across the lacquer cup from side to side to scrape the brush on; the latter should have the ends of the hairs trimmed exactly even with a pair of sharp scissors.

Scrape the brush as dry as possible on the wire, making a flat, smooth point at the same time.

Use the very tip of the brush to lacquer with, go very slow, and carry a steady hand.

Put on two coats at least. In order to make a very durable coat, blaze off with a spirit lamp or Bunsen burner, taking special pains not to burn the lacquer.

If the work looks gummy, the lacquer is too thick; if prismatic colors show themselves, the lacquer is too thin. In the former case, add a little alcohol; in the latter, place over the lamp, and evaporate to the desired consistency.

If the work is cheap, like lamp-burners, curtain fixtures, etc., the goods may be dipped. For this purpose use a bath of nitric acid, equal parts, plunge the goods in, hung on wire, for a moment, take out and rinse in cold water thoroughly, dip in hot water, the hotter the better, remove and put in alcohol, rinse thoroughly, and dip in lacquer, leaving in but a few minutes; shake vigorously to throw off all surplus lacquer, and lay in a warm place; a warm metal plate is the best to dry. Do not touch till cool, and the job is done. Lacquered work should not be touched till cold; it spoils the polish.

Sometimes drops will stand on the work, leaving a spot.

These drops are merely little globules of air, and can be avoided by shaking when taken out.

The best lacquer for brass is bleached shellac and alcohol; simply this, and nothing more.

In the preparation of goods for lacquering, care should be taken to polish gradually, *i. e.*, carefully graduate the fineness of materials until the last or finest finish. Then, when the final surface is attained, there will be no deep scratches, for, of all things to be avoided in fine work, are deep scratches beneath a high polish.

THE REAL INVENTOR OF THE BESSEMER PROCESS.

The late William C. Kelly, the world-famed inventor of the improved Bessemer process of making steel, was years ago, the proprietor of the Suanee Iron Works and Union Forge, in Lyon County, Ky. The metal produced at these works was taken from the furnace to the forge, where it was converted into charcoal blooms. These blooms had a great reputation for durability and quality, and were used principally for boiler plates and metal. It was while making the blooms at this place that Mr. Kelly made his great invention of converting iron into Bessemer steel, which Judge Kelly of Pennsylvania, at the Masonic Temple Theater last fall, termed the greatest invention of the age. The old process of making blooms was very expensive, owing to the great amount of charcoal required in its transformation, and Mr. Kelly conceived the idea of converting the metal into charcoal blooms without the use of fuel, by simply forcing powerful blasts of atmosphere up through the molten metal. His idea was that the oxygen of the air would unite with the carbon in the metal and thus produce combustion, refine the metal, and, by eliminating the carbon, wrought-iron or steel would be produced. When he announced his theory to his friends and to skilled iron workers, they scoffed, and were struck with astonishment that a man of Mr. Kelly's learning and practical iron-making knowledge would suggest such an idea as boiling metal without the use of fuel, and by simply blowing air through it.

His friends thought him demented, and discouraged him from wasting his time and money upon any such visionary scheme. Mr. Kelly was confident that his idea was a good one, and began making experiments, which he kept up with varying success for ten years, but the blooms were manufactured without the aid of fuel. It was generally known as

"Kelly's air boiling process," and was in daily use converting iron into blooms at his forge. Mr. Kelly's customers learned finally of the process, and, not understanding it, they advised him that they would not buy blooms made by any but the old and established method. This was the first difficulty placed in Mr. Kelly's way, and he was consequently compelled to carry on his work secretly, which subjected him to many disadvantages. Some English skilled workmen in Mr. Kelly's employ were familiar with his non-fuel process, and went back to England, taking the secret with them. Shortly after their arrival in Liverpool, Henry Bessemer, an English ironmaster, startled the iron world by announcing the discovery of the same process as Mr. Kelly's, and applied for patents in Great Britain and in the United States. Mr. Kelly at once made his application for a patent, and was granted one over Bessemer, the decision being that he was the first inventor and was entitled to the patent by priority.

The history of this remarkable invention is a lengthy one, and it is generally admitted by persons cognizant of the facts in the case that Bessemer's idea was secured from the English ironworkers employed by Mr. Kelly. Certain it is, however, that Mr. Kelly's invention and patents have heaped honors and wealth upon Bessemer, and he has been regarded as the greatest inventor of the nineteenth century, and the proper credit was always accorded him. Mr. Kelly's process was but barely successful until after it was perfected by Robert Musshult, a prominent English iron worker. Concerning the claims of the different persons, a prominent iron and steel manufacturer, the late James Park, of Pittsburg, once said: "The world will some day learn the truth, and in ages to come a wreath of fame will crown William Kelly, the true inventor, and that truth will never be effaced by time."

A NOVEL PLANING MACHINE.

A machine for planing the curved surfaces of propeller blades, so as to render them of uniform thickness and pitch, has been invented in England, and is herewith described. The principal feature is guiding and controlling the tool to travel on the curved surfaces, by a cast-iron former.

The machine is provided with two tables, which can be rotated through a given range by a worm-wheel and worm, so that the inclinations of both tables can be simultaneously varied, and to an equal degree. One of the tables carries a cast-iron copy of the back or front of the blade it is desired to produce, while on the other table the actuall propeller is

secured, one of its blades occupying a similar position on this table to that of the copy on the other.

To insure the rigidity of the work, the table on which the propeller is fixed has its upper surface shaped to correspond with the form of the blade on it, and is finally brought to the exact shape necessary by a coating of Portland cement. A cut ⅜ in. deep can be taken without springing the blade. The propeller is also held by being mounted on a duplicate of the propeller shaft, which is secured to the table. The cutting is done by a tool of the ordinary type, work being commenced at the top of the blade, and a self-acting traverse is used to feed the tool toward the boss.

The tool-holder is connected by a system of levers with a similar holder at the other end of the slide, carrying a follower, which moves over the copy, and thus guides the cutting tool. As the boss is approached, the inclination of the two tables to the horizontal is altered by the worm gear, so as to limit the necessary vertical motion of the tool. In this way all the blades of the propeller may be successfully machined, back and front, and will then be of identical form and thickness, and set at the same angle to the propeller shaft.

One of the propellers lately turned out by this machine was 6 ft. in diameter, with an increasing pitch, the mean of which was 7 ft. 9 in., the thickness in the center of the blades varying from ⅛ in. at the top to 1 in. at the boss. The breadth was 21 in., and the widest part and the cross section showed a regular taper from the center line to a knife-edge.

The importance of accuracy and uniformity in the shape of the blades of propellers for high-speed vessels is now generally acknowledged, and the machine we have described promises to form a very useful addition to the plant of a modern marine engineering establishment.

HOW TO REMOVE RUST FROM IRON.

A method of removing rust from iron consists in immersing the articles in a bath consisting of a nearly saturated solution of chloride of tin. The length of time during which the objects are allowed to remain in the bath depends on the thickness of the coating of rust; but in ordinary cases twelve to twenty-four hours is sufficient. The solution ought not to contain a great excess of acid if the iron itself is not to be attacked. On taking them from the bath, the articles are rinsed in water and afterward in ammonia. The iron, when thus treated, has the appearance of dull silver; but a simple polishing will give it its normal appearance.

HOW TO ANNEAL STEEL.

Owing to the fact that the operations of rolling or hammering steel make it very hard, it is frequently necessary that the steel should be annealed before it can be conveniently cut into the required shapes for tools.

Annealing or softening is accomplished by heating steel to a red heat, and then cooling it very slowly, to prevent it from getting hard again

The higher the degree of heat the more will steel be softened, until the limit of softness is reached, when the steel is melted.

It does not follow that the higher a piece of steel is heated the softer it will be when cooled, no matter how slowly it may be cooled; this is proved by the fact that an ingot is always harder than a rolled or hammered bar made from it.

Therefore, there is nothing gained by heating a piece of steel hotter than a good bright cherry red; on the contrary, a higher heat has several disadvantages: if carried too far, it may leave the steel actually harder than a good red heat would leave it. If a scale is raised on the steel, this scale will be harsh, granular oxide of iron, and will spoil the tools used to cut it. It often occurs that steel is scaled in this way, and then, because it does not cut well, it is customary to heat it again, and hotter still, to overcome the trouble, while the fact is, that the more this operation is repeated, the harder the steel will work, because of the hard scale and the harsh grain underneath. A high scaling heat, continued for a little time, changes the structure of the steel, destroys its crystalline property, makes it brittle, liable to crack in hardening, and impossible to refine.

Again, it is a common practice to put steel into a hot furnace at the close of a day's work, and leave it there all night. This method always gets the steel too hot, always raises a scale on it, and, worse than either, it leaves it soaking in the fire too long, and this is more injurious to steel than any other operation to which it can be subjected.

A good illustration of the destruction of crystalline structure by long-continued heating may be had by operating on chilled cast-iron.

If a chill be heated red hot and removed from the fire as soon as it is hot, it will, when cold, retain its peculiar crystalline structure; if now it be heated red hot, and left at a moderate red for several hours; in short, if it be treated as steel often is, and be left in a furnace over night, it will be

found, when cold, to have a perfect amorphous structure, every trace of chill crystals will be gone, and the whole piece be non-crystalline gray cast-iron. If this is the effect upon coarse cast-irons, what better is to be expected from fine cast-steel?

A piece of fine tap steel, after having been in a furnace over night, will act as follows:

It will be harsh in the lathe and spoil the cutting tools.

When hardened, it will almost certainly crack; if it does not crack, it will have been a remarkably good steel to begin with. When the temper is drawn to the proper color and the tap is put into use, the teeth will either crumble off or crush down like so much lead.

Upon breaking the tap, the grain will be coarse and the steel brittle.

To anneal any piece of steel, heat it red hot; heat it uniformly and heat it through, taking care not to let the ends and corners get too hot.

As soon as it is hot, take it out of the fire, the sooner the better, and cool it as slowly as possible. A good rule for heating is to heat it at so low a red that, when the piece is cold, it will still show the blue gloss of the oxide that was put there by the hammer or rolls.

Steel annealed in this way will cut very soft; it will harden very hard, without cracking, and, when tempered, it will be very strong, nicely refined, and will hold a keen, strong edge.

THE BURSTING AND COLLAPSING PRESSURE OF SOLID DRAWN TUBES.

The following table gives the bursting and collapsing pressure of solid drawn tubes:

Diameter.	Bursting Pressure.	Collapsing Pressure.	Difference.
3¼	4800	3300	1500
3⅛	4500	3150	1350
3	4500	3500	1000
2¾	5200	3500	1700
2½	5000	3600	1400
2¼	5900	4500	1400
2	5900	4900	1000
1¾	5600	4000	1600

In this table it will be noticed that the bursting strength exceeds the collapsing strength, and that the difference increases with the diameter, as shown in the last column.

MINERAL WOOL.

Mineral wool is the name of an artificial product now used for a great variety of purposes, chiefly, however, as a non-conductor for covering steam surfaces of whatever character. It is largely used for this, and the underground steam pipes of the New York Steam Company are insulated with it.

Mineral wool is made by converting vitreous substances into a fibrous state. The slag of blast furnaces affords a large supply of material suitable for this purpose. The product thus obtained is known as slag wool. For the reason that slag is seldom free from compounds of sulphur, which are objectionable in the fiber, a cinder is prepared from which is made rock wool. These products comprise the two kinds of mineral wool; they are not to be distinguished from it, but from each other.

The resemblance of the fibers to those of wool and cotton has given the names of mineral wool and silicate cotton to the material, but the similarity in looks is as far as the comparison can be followed. The hollow and joined structure of the organic fiber, which gives it flexibility and capillary properties, is wanting in the mineral fibre. The latter is simply finely-spun glass of irregular thickness, without elasticity or any such appendages as spicules, which would be necessary for weaving purposes. The rough surfaces and markings of the fiber can only be detected under a strong magnifying glass.

Aside from its uses as covering for hot surfaces, it is also largely employed for buildings. A filling of mineral wool in the ground floor, say two inches thick, protects against the dampness of cellar; in the outside walls, from foundation to peak, between the studding, it will prevent the radiation of the warmth of interior, and will destroy the force of winds, which penetrate and cause draughts; in the roof it will retain the heat which rises through stair-wells, bringing about regularity of temperature in cold weather; the upper rooms will not receive the heat of the summer sun, and store it up for the occupants during the night, but remain as cool as those on the floor below; the water fixtures in bath-rooms, closets and pantries will not be exposed to extremes of heat and cold.

Analysis of mineral wool shows it to be a silicate of magnesia, lime, alumina, potash and soda. The slag-wool contains also some sulphur compounds. There is nothing organic in the material to decay or to furnish food and comfort to insects and vermin; on the other hand, the fine fibers

of glass are irritating to anything which attempts to burrow in them. New houses lined with mineral wool will not become infested with animal life, and old walls may be ridden of their tenants by the introduction of it.

Mineral wool is largely used for car linings, in which service it reduces the noise of travel greatly. Aside from those mentioned, it can be applied generally in the arts for all purposes where a non-conductor or a shield is required, and the experience of several years show that it is both serviceable and cheap.

NICKEL PLATING SOLUTION.

According to the *Bulletin Internationale de l'Electricite*, the following solution is employed for nickel plating by several firms in Hainault. It is said to give a thick coating of nickel firmly and rapidly deposited. The composition of the bath is as follows:

Sulphate of nickel	1	lb.
Neutral tartrate of ammonia	11.6	oz.
Tannic acid with ether	.08	oz.
Water	16	pints.

The natural tartrate of ammonia is obtained by saturating tartaric acid solution with ammonia. The nickel sulphate to be added must be carefully neutralized. This having been done, the whole is dissolved in rather more than three pints of water, and boiled for about a quarter of an hour. Sufficient water is then added to make about sixteen pints of solution, and the whole is finally filtered. The deposit obtained is said to be white, soft and homogeneous. It has no roughness of surface, and will not scale off, provided the plates have been thoroughly cleaned. By this method good nickel deposits can be obtained on either the rough or prepared casting, and at a net cost which, we are told, barely exceeds that of copper plating.

HOW GAMBOGE IS PREPARED.

Gamboge is a gum, and an average gamboge tree is said to yield annually sufficient to fill three bamboo cylinders, each about 18 to 20 inches long and 1½ inches in diameter. It takes about a month to fill a cylinder. When full the bamboo is rotated over a fire to allow the moisture to escape and the gum to harden sufficiently to admit of being removed.

PROOF OF THE EARTH'S MOTION.

Any one can prove the rotary motion of the earth on its axis by a simple experiment.

Take a good-sized bowl, fill it nearly full of water and place it upon the floor of a room which is not exposed to shaking or jarring from the street.

Sprinkle over the surface of the water a coating of lycopodium powder, a white substance which is sometimes used for the purposes of the toilet, and which can be obtained at almost any apothecary's. Then, upon the surface of this coating of powder, make with powdered charcoal a straight black line, say an inch or two inches in length.

Having made this little black mark with the charcoal powder on the surface of the contents of the bowl, lay down upon the floor, close to the bowl, a stick or some other straight object, so that it shall be exactly parallel with a crack in the floor, or with any stationary object in the room that will serve as well.

Leave the bowl undisturbed for a few hours, and then observe the position of the black mark with reference to the object it was parallel with.

It will be found to have moved about, and to have moved from east to west, that is to say, in that direction opposite to that of the movement of the earth on its axis.

The earth, in simply revolving, has carried the water and everything else in the bowl around with it, but the powder on the surface has been left behind a little. The line will always be found to have moved from east to west, which is perfectly good proof that everything else has moved the other way.

WHY THE COMPASS VARIES.

The compass, upon which the sailor has to depend, is subject to many errors, the chief of which are variation and deviation; that is, the magnetic needle rarely points to the true north, but in a direction to the right or left of north, according to its error at the time and place. The deviation of the compass comprises those errors which are local in their character; that is, due to the effect of immediately surrounding objects, such as the magnetism of the ship itself; this is sometimes very great in an iron ship.

The variation of the compass varies with the position of the ship, as shown by these curves of variation. Thus, from Cape Race to New York the variation of the compass changes from 30° W. to less than 10° W.; and from Cape Race to

New Orleans from 30° W. to more than 5° E., the line of no variation being indicated by the heavier double line stretching from the coast near Charleston down through Puerto Rico and the Windward Islands to the northeastern coast of South America.

To illustrate these variation curves more clearly, a chart has been made upon which variation curves are plotted for each degree. This illustrates very strikingly the positions of the magnetic poles of the earth, which do not by any means coincide with the geographic poles. On the contrary, there are two northern magnetic poles and two southern; up north of Hudson's Bay, at the point where these curves converge, there is one magnetic pole, and another to the northward of Siberia. Similarly, there are two in the southern hemisphere, and these four poles of this great magnet, the earth, are constantly but slowly shifting their positions, and just so constantly and surely does the magnetic needle obey these varying, but ever-present forces, seldom pointing toward the pole which man has marked off on his artificial globe, but always true to the great natural laws to which alone it owes allegiance. The small figures with plus and minus signs at various places on this chart indicate the yearly rate of change of variation, and this rate varies at different positions on the chart. Thus, near the Cape Verde Islands it is plus $\frac{9}{10}$; here the variation increases $\frac{9}{10}$ of a minute a year; farther to the southward, near the South American coast, it is plus $7\frac{4}{10}$, and to the northward, near the Irish Channel, it is minus $7\frac{8}{10}$. Fortunately, however, these changes are small and comparatively regular, and their cumulative effect can be allowed for, when large enough to make it necessary to do so.

THE BANK OF ENGLAND DOORS.

The Bank of England doors are now so finely balanced that a clerk, by pressing a knob under his desk, can close the outer doors instantly, and they cannot be opened again except by special process. This is done to prevent the daring and ingenious unemployed of the metropolis from robbing the bank. The bullion department of this and other banks are nightly submerged several feet in water by the action of machinery. In some banks the bullion department is connected with the manager's sleeping room, and an entrance cannot be effected without shooting a bolt in the dormitory.

KEEPING TOOLS.

Keep your tools handy and in good condition. This applies everywhere and in every place, from the smallest shop to the greatest mechanical establishment in the world. Every tool should have its exact place, and should always be kept there when not in use.

Having a chest or any receptacle with a lot of tools thrown into it promiscuously, is just as bad as putting the notes into an organ without regard to their proper place. If a man wants a wrench, chisel or hammer, it's somewhere in the box or chest, or somewhere else, and the search begins. Sometimes it is found — perhaps sharp, perhaps dull, maybe broken; and by the time it is found he has spent time enough to pay for several tools of the kind wanted.

The habit of throwing every tool down, anyhow, and in any way, or any place, is one of the most detestable habits a man can possibly get into. It is only a matter of habit to correct this. Make an inflexible end of your life to "have a place for everything and everything in its place."

It may take a moment more to lay a tool up carefully after using, but the time is more than equalized when you want to use it again, and so it is time saved. Habits, either good or bad, go a long ways in their influence on men's lives, and it is far better to establish and firmly maintain a good habit, even though that habit has no special bearing on the moral character, yet all habits have their influence.

Keeping tools in good order, and ready to use, is as necessary as keeping them in the proper place. To take up a dull saw, or a dull chisel, and try to do any kind of work with it, is worse than pulling a boat with a broom, and it all comes from just the same source as throwing down tools carelessly — habit, nothing more or less. To say you have no time to sharpen is worse than outright lying, for, if you have time to use a dull tool, you have time to put it in good order.

AN IMPROVED SCREW-DRIVER.

A screw-driver has been made in Philadelphia with the handle in two parts, said parts being capable of rotating one upon the other. A stop-pin and pawl limit the movement of the shank in one direction, while the top of the handle will move backward without turning the shank. The mechanism appears to be very similar to the principle of a stem-winding watch.

THE EFFECT OF MAGNETISM ON WATCHES.

At a meeting of the Western Railway Club, Mr. E. M. Herr, superintendent of telegraph of the Chicago, Burlington & Quincy Railroad, read the following paper:

A magnet is a body, usually of steel, having the property, when delicately poised and free to turn, of pointing toward the north, and of attracting and causing to adhere to its ends or poles, pieces of iron, steel, and some other substances. Materials which are attracted by a magnet are called magnetic, and it is because the rapidly moving parts of a watch are in general, made, in part at least, of magnetic material, that these timepieces are affected by that peculiar force magnetism.

Were magnetic substances only affected while a magnet is near them, there would be little difficulty as far as watches are concerned. Such, unfortunately, is not the case, as certain materials, steel more than any other, are not only attracted by a magnet, but become themselves permanent magnets when brought into contact with or even in the vicinity of a magnetized body. It is to the latter property of steel, namely, becoming permanently magnetized by the approach of a magnet without coming in contact in any way with it, that causes trouble with watches.

Again, a small piece of steel is much more easily magnetized than a large one; consequently, the small and delicate parts of a watch are most likely to be affected. These are found in the balance wheel and staff, hair spring, fork and escape wheel, and are the very ones in which magnetism causes trouble on account of the extreme accuracy and regularity with which they must perform their movements. It is, in fact, upon the uniformity in the motion of the balance wheel, that the timekeeping qualities of the watch depend.

In a magnetized watch this wheel, as well as all other steel parts, become permanent magnets, each tending to place itself in a north and south line, and also to attract and to be attracted by the others; all of which, it is hardly necessary to add, tends to affect its reliability as a timepiece. How small a variation in each vibration of the balance wheel will cause a serious error in the daily rate of a watch, is easily realized when attention is given for a moment to the number of double vibrations this wheel makes in 24 hours.

This varies in different watches from 174,000 to 216,000, and the variation of a single vibration in this number will cause a greater error than is sometimes found in the best watch movements. It is therefore true that the variation in

each vibration of the balance wheel of 1-200,000 part of the time of such vibration, or in actual time about the 1-500,000 part of a second, will prevent the watch rating as a strictly first-class time piece.

I wish to state, however, that there are very few watches made of ordinary materials which are absolutely free from magnetism. This may seem like a sweeping statement, but, after taking considerable pains to verify or disprove of it, I am convinced that it is substantially correct.

Why this should be so becomes evident when we consider that a few sharp blows upon a piece of steel held in the direction of a dipping needle suffice to sensibly magnetize it, and then think of the numerous mechanical operations that have to be performed upon each small piece of steel in the moving parts of a watch before it becomes a finished product.

In order to determine, if possible, to what extent magnetism prevails in watches, I have examined and tested for magnetism 28 watches carried by persons other than train or engineer men, with the following result: Three were very seriously magnetized; one to such an extent that it could not be regulated closely; twenty barely perceptibly affected, possibly, but the normal amount due to the process of manufacture, and in but four could no magnetism be detected.

On account of the steel parts of a locomotive being magnetized during the process of construction, and by severe usage in a similar manner to those of a watch, it has been claimed that the watches of engineers are constantly subjected to the action of the magnetic forces, and cannot therefore keep as good time as other watches.

I have examined for magnetism the different parts of a number of locomotives in actual service, and, although they were in general found to be magnetic, they are so slightly charged as to render it almost certain they could have no influence upon the rate of a watch, and would surely produce less effect upon it than the originally slightly magnetized parts of the watch itself. That this amounts to practically nothing, is proven by the large number of finely rated watches now in use in which magnetism is apparent.

As proof of the statement that engine-men's watches are not, as a rule, more highly charged with magnetism than those of men engaged in other occupations, the watches of twenty locomotive engineers were tested. Of these none were found heavily charged with magnetism; but two more than normal; twelve with a barely perceptible charge, and in six none could be detected, showing actually less magnet-

ism in these than in the twenty-eight watches previously examined, none of which were carried on a locomotive, a result probably due to the fact that engineers, as a rule, are very careful of their watches, and are less apt to bring them in dangerous proximity to a dynamo than those not concerned in running trains, and in whom a well-regulated watch is less important. This, I take it, would surely be the case did they all understand that a watch is likely to be entirely disabled by bringing it near a dynamo or motor in operation. It therefore seems important that all to whom accurate time is a necessity, should be carefully instructed as to where the danger lies.

So much has recently been written about the magnetizing of watches that many persons approach any kind of electrical apparatus with caution. Even a battery of ordinary gravity, or LeClanche cells, is regarded with suspicion, while a storage battery is thought almost as dangerous as a dynamo.

Others, on the other hand, do not even know that a dynamo is dangerous to watches. It should be borne in mind that it is not electricity which affects watches, but magnetism, and that magnets are the seats of danger. It is the powerful electro-magnets in dynamos and motors that magnetize watches, and not the strong currents of electricity generated or consumed by them. True, there is a magnetic field about every current of electricity, but it is so very slight that no effect is produced on watches worn in the pocket.

Having spoken of the evils of magnetism in watches, it is, perhaps, proper to add a few words regarding its prevention. The best and most certain way to prevent a watch becoming magnetized is to never allow it to come near a magnet. Unfortunately, in the present age, this is a difficult matter, as no one can say how soon they may find it necessary to be in the vicinity of a dynamo in operation or be seated in a car propelled by an electro-motor.

The only practical protection to watches from magnetism of which I have been able to learn consists essentially of a cup-like casing of very pure soft iron surrounding the works of the watch, which is known as the anti-magnetic shield. That this device is a protection from the effects of magnetism upon watches, there can be no doubt, but that it prevents magnetizing under all circumstances, even its inventor, I believe, does not claim.

It therefore becomes important to know how far our watches are safe when supplied with this protection, and

where to draw the danger line for the protected, as well as the unprotected watch. In order to throw some light upon this question, the following tests were made:

First, to discover to what extent magnetic bodies placed within the shield were protected from external magnetic forces ; second, in how strong a magnetic field it was necessary to place a watch protected by this device to effect its rate by magnetization.

While no pretense of scientific accuracy or precision was made in these tests, it is believed they are sufficiently accurate for scientific purposes.

The first test was made by filling an inverted shield half full of water, on the surface of which a very light magnetized steel needle was caused to float. In a similarly shaped cup, made of porcelain, another needle, in all respects like the first, was also floated. A horseshoe magnet was then brought near each, and found to affect each needle equally, at the following distances : in shield, 6 in. ; in porcelain cup, 13½ in.

Distance below a ¾-in. wooden board, upon which shield and cup were placed, at which needles could be just reversed by magnet — in shield, 3¾ in. ; in porcelain cup, 8¼ in. With just enough water to cover the bottom of shield, the following distances for equal effects were observed : first exposure in shield, 8 in. : first exposure in porcelain cup, 20 in. ; second exposure in shield, 12 in. : second exposure in porcelain cup, 30 inches.

Since the intensity of a magnetic force varies inversely as the square of the distance, the above results indicate that to produce like effects, at equal distances, magnetic forces from five to six times as strong would be required, with bodies inclosed within the shield, than with those not so protected.

The second test was made with watches of different makes, all furnished with the shield. Space will not permit my going into the details of these tests, which extended over several months. I will only say that they in general consisted in obtaining the rating and performance of the watch before and after it was exposed to magnetic influences. The exposure consisted in placing it nearer and nearer to the pole pieces of a powerful arc light dynamo and observing the rate before and after each exposure. After many tests of this kind, the conclusion was reached that a watch carefully and properly shielded could be safely placed not nearer than 4 in. to the pole pieces of a 20 arc light Ball dynamo. When brought nearer they were without exception magnet-

ized to a greater or less degree, the amount depending largely upon the time of such exposure.

Watches are now being made, however, which it is claimed are entirely non-magnetic and unaffected by the strongest magnetic fields met with in practice. Several such watches were also examined and tested. They were furnished with a balance-wheel, hair-spring, fork and escape wheel made of an alloy of non-magnetic metals in which palladium is the principal component. The first of these watches tested was furnished only with a non-magnetic balance and hair-spring, and had a steel fork and escape wheel. This watch is instantly stopped when brought near a powerful dynamo.

Other movements were then tried, in which all of the rapidly moving parts were of non-magnetic material. These could not be stopped by the field magnets of the most powerful arc light dynamos, although when placed in actual contact with the pole piece the balance-wheel was seen to vibrate less freely, probably due to the attraction of the staff and pivots, which were of steel. The rate of the watch was not, however, altered by this test.

A hair-spring made of this non-magnetic alloy was also delicately suspended in still air and subjected to the action of a powerful horseshoe magnet without developing the slightest observable magnetic effect.

One of our best-known American watch manufacturing firms is now making a non-magnetic watch on a plan similar to that just described; others will probably soon follow, hastening the day when a watch thoroughly protected or inherently insensible to magnetism will be as common, and considered as necessary to the successful keeping of correct time as the adjustment for temperature and position is already.

HOW BARRELS ARE MADE.

Barrels are now being made of hard and soft wood, each alternate stave being of the soft variety, and slightly thicker than the hard-wood stave. The edges of the staves are cut square, and, when placed together to form the barrel, the outsides are even, and there is a V-shaped crack between each stave from top to bottom. In this arrangement the operation of driving the hoops forces the edges of the hard stave into the soft ones, until the cracks are closed, and the extra thickness of the latter causes the inner edges to lap over those of of the hard-wood staves, thus making the joints doubly secure.

FACTS ABOUT IRON CASTINGS.

Some experience of the changes of shape which castings undergo by reason of shrinkage strains is necessary, in order to proportion them correctly. I have seen numerous massive and very strong looking castings fracture during cooling, or a long time afterward while lying in the yard untouched, or while being machined; the reason being that excessive contraction in one portion had put adjacent parts into a condition of great tension. By putting an excess of metal into some vulnerable point of a casting, is introduced an element of weakness, and almost a certainty of its breaking by reason of the internal shrinkage strains. It is not the excess of metal in itself which gives rise to these strains, but the position in which it is placed relatively to other sections. Thus a lump of metal cast in juxtaposition to a thinner portion will not break the latter, so long as it is able to shrink freely upon itself. But if placed between two thinner portions, it may fracture them by its shrinkage. Hence the great aim is to so design castings that all portions thereof thall cool down with approximate uniformity. A founder learns much from the behavior of cast-iron pulleys and light wheels. As they are so light and weak, proportioning must be correctly observed, and when customers ask for a "good, strong boss" or "strong arms," the request is one which, if complied with in the manner described; that is, by unduly increasing the metal, will either fracture the pulley or wheel, or bring it near to breaking limit. In all castings "strong" is a relative term, that form or size being strongest which harmonizes as regards general proportions. In a light pulley, three different conditions may exist: 1. All parts may cool down alike, or nearly so; 2. The rim may cool long before the arms and boss; 3. The arms and boss may cool before the rim. In the first case, the pulley will be strong and safe. In the second, the rim, in cooling, will set rigidly, but the arms and boss will continue shrinking, each arm exerting an inward pull on the rim, and various results may follow. First, the strain may simply cause the arm to straighten; or, in less favorable conditions, and especially if straight arms, or arms but slightly curved, be used, the arms may fracture near the rim, but seldom near the boss. Or, if the rim be weaker than the arm, fracture will take place, or the pulley may be turned, and then break. In the third case, the arms and boss cooling before the rim, they are compressed by the shrinkage of the latter, and the arms may then become fractured, if curved; or, if straight, may prevent the rim from

coming inward, and so break it. In most cases, fracture occurs from the mass of metal in the boss. As a single instructive example out of many, I may quote that of a pair of 2 ft. 6 in. pulleys, fast and loose, which had been running for several years, the fast pulley had a boss 6 in. in diameter, the loose pulley one of 5 in. only, and both were bored to 3 in. By the accidental falling of a bar of iron, both were broken. The rim of the fast pulley was at once pulled in, while the loose pulley remained level at the point of fracture. This illustrates the presence of tension in the rim, due to the larger boss, and this tension had been present since the pulley was made. The pulley with the 5 in. boss was probably much stronger than that with the six in. boss. In fast pulleys, and in wheels keyed on, the necessary strength around the keyway may be obtained by the use of keyway bosses, without increasing the entire diameter Where large bosses are unavoidable, as in some deep, double-armed pulleys, or in spur wheels keyed onto large shafts, shrinkage is assisted by opening out the mold around the bosses, and removing the central core, thereby accelerating the radiation of heat, and further by cooling them with water from a swab brush when at a low red or black heat. Many a casting is saved in this way Another method is to split the boss with plates, and bond or bolt it together afterward. When casting flywheels with wrought-iron arms, the rim is first cast around the arms and allowed to cool nearly down before the boss is poured. If the latter were cast at the same time as the rim, it would set first, and, by preventing the arms from coming inward, would put tension upon the rim.

Where aggregations of metal occur in castings, they may, if the castings be too strong to fracture, cause an evil of a secondary character, known as "drawing;" in other words, the metal is put into a condition of internal stress, and becomes open and spongy in consequence. "Feeding" tends to diminish this evil; but much can often be done by lightening the metal with cores, chambering out, or reducing the metal massed in certain places by other means. There is a difference in the behavior of cast-iron and of gun metal, of which advantage may be taken in small, light castings. Designs which will not stand in cast-iron or steel will stand in gun metal, hence the latter may be useful in cases of difficulty.

Sharp angles very often lead to fracture. When brackets, ribs, slugs, etc., are cast on work, the corners should never be left square or angular, for, if there be much disproportion

of metal, fracture will almost certainly commence in the angles.

I have already alluded to the "straining" which large plated and heavy castings undergo, so that the sides and faces increase in dimensions, becoming more or less rounded. The main reason is, I think, that the metal round the central portions does not cool so rapidly as that at the sides. The outsides radiate heat quickly, and shrink to their full extent; but the middle rib or ribs, and the central portions of the plate, retain their heat longer, and hold the sides in a condition of tension, thus forcing them to bulge or become round. When the central portions cool, the outsides are too rigid to yield to the inward pull. This refers to framed hollow work. When plates "gather" or increase in thickness, it is due mainly to the lifting of the cope, from insufficient weighting. When a cubical mass of metal shows no shrinkage, this is due to the pressure of the entire mass compressing the sand on every side.

Briefly stated, then, in deciding the proper contraction allowance for a pattern, I should take into consideration its mass, the manner in which it is molded and cast, the presence or absence of cores, and the nature of the same, its general outline, and the character of the metal. For a heavy solid casting in iron, I should allow considerably less than the normal contraction for iron; for a similar casting in steel, more than the normal contraction for steel; for a heavy casting in gun metal, less than the normal contraction for gun metal. The precise allowance in any case must be regulated by circumstances. For the vertical depth of a shallow casting, very little shrinkage, if any, should be allowed; for a deep casting, the full amount. Then, again, a mold, with dry sand cores of moderate or large size, will not allow the casting to shrink so much as if the cores were of green sand, or were altogether absent. For hard and chilled iron, the shrinkage will be at its maximum; for strong mottled iron, at its maximum; and for common gray metal, at about the average.

FLEXIBLE GLASS.

An article called flexible glass is now made by soaking paper of proper thickness in copal varnish, thus making it transparent, polishing it when dry, and rubbing it with pumice stone. A layer of soluble glass is then applied and rubbed with salt. The surface thus produced is said to be as perfect as ordinary glass

COMMON NAMES OF CHEMICAL SUBSTANCES

Aqua Fortis	Nitric Acid
Aqua Regia	Nitro-Muriatic Acid
Blue Vitriol	Sulphate of Copper
Cream of Tartar	Bitartrate of Potassium
Calomel	Chloride of Mercury
Chalk	Carbonate of Calcium
Salt of Tartar	Carbonate of Potassa
Caustic Potassa	Hydrate of Potassium
Chloroform	Chloride of Gormyle
Common Salt	Chloride of Sodium
Copperas or Green Vitriol	Sulphate of Iron
Corrosive Sublimate	Bichloride of Mercury
Diamond	Pure Carbon
Dry Alum	Sulphate Aluminum and Potassium
Epsom Salts	Sulphate of Magnesia
Ethiops Mineral	Black Sulphide of Mercury
Fire Damp	Light Carbureted Hydrogen
Galena	Sulphide of Lead
Glucose	Grape Sugar
Goulard Water	Basic Acetate of Lead
Iron Pyrites	Bisulphide of Iron
Jeweler's Putty	Oxide of Tin
King Yellow	Sulphide of Arsenic
Laughing Gas	Protoxide of Nitrogen
Lime	Oxide of Calcium
Lunar Caustic	Nitrate of Silver
Mosaic Gold	Bisulphide of Tin
Muriate of Lime	Chloride of Calcium
Niter of Saltpeter	Nitrate of Potash
Oil of Vitriol	Sulphuric Acid
Potash	Oxide of Potassium
Red Lead	Oxide of Lead
Rust of Iron	Oxide of Iron
Sal Ammoniac	Muriate of Ammonia
Slacked Lime	Hydrate of Calcium
Soda	Oxide of Sodium
Spirits of Hartshorn	Ammonia
Spirit of Salt	Hydrochloric or Muriatic Acid
Stucco, or Plaster Paris	Sulphate of Lime
Sugar of Lead	Acetate of Lead
Verdigris	Basic Acetate of Copper
Vermilion	Sulphide of Mercury
Vinegar	Acetic Acid (diluted
Volatile Alkali	Ammonia
Water	Oxide of Hydrogen
White Precipitate	Ammoniated Mercury
White Vitriol	Sulphate of Zinc

TO CLEAN RUSTY STEEL.

Mix ten parts of tin putty, eight parts of prepared buck's horn, and twenty-five parts of spirit of wine to a paste. Cleanse the steel with this preparation, and finally rub off with soft blotting paper.

HINTS ON PATTERN-MAKING.

The pattern shop is one of the most important departments in a plant for the manufacture of machinery. It is here that the plans of the mechanical engineer are first developed, and upon the skillful manner in which the patterns are constructed and those plans faithfully carried out, depends much of the future success in the manufacture of the machine. The skillful pattern-maker, by accurate calculations for shrinkage, finishing and the contingencies of the foundry, may save a great amount of labor and annoyance in the machine shop. It is unreasonable to expect perfect castings from imperfect patterns, and the molder is often blamed for imperfections of the castings when the fault may be traced to an imperfect pattern. Molders as a class have sins enough of their own to answer for without the addition of the sins of the pattern-maker. Patterns are as a rule necessarily expensive, and should be carefully constructed, so that they will retain their shape and proportions for future use, and to this end the selection of materials and the manner of joining the several parts together becomes an important item. For all ordinary purposes, especially for patterns of considerable size, good, clear, well-seasoned white pine is the best, and to obtain the best results it should be seasoned in the open air in the natural way. The sap of all the woods contains a large percentage of water, and to get rid of this is the object in seasoning. Pine wood, besides water, contains a large percentage of turpentine in the sap, and in seasoning it, it is desirable to retain as much of this as possible, as it dries to a hard substance when seasoned in the open air, and helps in a measure to fill up the pores of the wood, and renders it close and more impervious to water, and less liable to be affected by dampness. Kiln-dried lumber, although extensively used at the present time, is not as good for this purpose. The heat and moisture used for this purpose expels, not only the water, but other ingredients, which leaves the grain open and brash, and patterns made from such materials are more liable to absorb dampness and warp than otherwise. In constructing patterns, especially those of considerable size, it is customary to build them up of several pieces glued together; this makes more reliable work, provided good glue is used and proper care manifested in the manner of putting them together. No two pieces should be glued together with grain crossing at right angles, for, no matter how dry the lumber may be, there will always be some shrinkage,

and, as lumber shrinks, almost entirely, in its transverse section, it is sure to warp, unless the glue gives way so as to allow each part to shrink in its natural direction. In either case the pattern will be unfit for further use until it is repaired. It is not good practice either, to glue up stuff for patterns with the grain of each piece running parallel with the other, as such patterns are deficient in strength, and are liable to split. The most practical way is to arrange the several pieces so that, when put together, the grain will run diagonally across each piece, at an angle of about twenty-five or thirty degrees. Pattern stuff prepared in this manner will have sufficient strength to prevent splitting by use and handling, and the tendency for warping will, to a great extent, be avoided. In building up circles, the cants should be short, and cut lengthwise of the grain as far as possible, so that the grain of each course as it is laid together to break points, may cross each other diagonally. It is customary with some pattern-makers to use nails or birds in each course as it is laid up, but pegs made of maple or hickory are much better, and, when the stuff is sufficiently thin to admit of it, the common pegs used in shoe shops are very cheap and convenient. The advantage of using pegs instead of brads or nails is, that, being driven in glue, they hold better, and the cants are not as liable to spring apart when exposed to the warm, damp sand in the foundry; besides, they never give the workman any trouble when turning it; and experience has demonstrated that patterns put together in this manner are much more durable than otherwise. Some pattern-makers use but little judgment in the use of glue, and seem to have an idea that the more glue they can get between two surfaces the better; yet, every experienced mechanic knows that exactly the reverse is the case. With a good joint and clear, fresh, thin glue, the least that is retained between the two surfaces the better and stronger will be the joint. In hot weather glue soon sours, turns black and becomes rancid; when in this condition, its strength is impaired and it is unfit for use. Alcohol mixed with it will prevent souring, but, as soon as it is healed up, the alcohol evaporates, and its effects are lost. The most effective preventive is sulphuric acid, but the acid should not be applied clear. For an ordinary glue-pot about fifteen drops of the acid mixed with a couple of spoonfuls of water may be applied; while this in no way impairs the strength of the glue, it will effectually prevent souring, and keep it fresh and clear.

For small gear patterns that are to be in constant use, cut

patterns of iron or brass are no doubt the best and cheapest in the end; but, if wood patterns are required, they should be made of some harder wood than pine ; mahogany or cherry is considered the best for such work. After the hub is turned to the proper size and width of face, the blanks for the teeth may be glued on and dressed in their places. With large, wide-faced gears, it is not convenient to do so ; the blanks for the cogs are usually glued to dovetailed slips, or the dovetailed formed on the under side of the blank so that, when fitted to the rim, or dressed off, and laid out, they may be removed for the convenience of finishing them. The dove-tails should be a perfect fit, and the blank well fitted to the rim; otherwise they will vary the pitch when dressed and replaced again. In constructing patterns for heavy castings, such as lathe and engine beds, the careful and even distribution of metal in each part is an important consideration, and, in order to give some particular part the requisite strength to withstand a heavy strain, it is sometimes necessary to put more metal in some other part where it is not needed in order to prevent the casting from being distorted in shape or cracked by the unequal construction caused by one part cooling faster than another. With the framework for lighter machinery the same allowance for shrinkage must be provided for. But where a frame is composed of several parts, some of which are much lighter than others and yet it is necessary that the whole should be cast together, it is well to make the lighter portions in curves as far as the nature of the work will permit. Sharp edges and square corners should also be avoided as far as possible. A small cove in each corner will add much to the convenience of molding, besides adding to the strength of the casting and insure it against cracks, which are liable to open at these points by shrinkage in cooling.

The pattern-maker should also exercise good judgment in making provision for withdrawing the pattern from the sand; but, as no two patterns are just alike in this respect, no definite rule can be followed. In intricate patterns, which require considerable skill and care on the part of the molder in withdrawing them from the sand, if the nature of the work will admit of it, considerable more draft should be allowed for this reason. But plain patterns may be nearly straight, provided their surface is perfectly smooth. For much draft, especially with gearing, is very objectionable, for it is impossible for such gearing to run together accurately, and bear the whole length of the tooth or cog, unless they are either chipped and filled, or planed straight. If gear patterns are made accurate and true,

and the face of the cogs perfectly smooth, there will be no difficulty in molding them if they are nearly or quite straight. All patterns before being used should be well covered with at least two coats of pure shellac varnish. After applying the first coat, and when it is perfectly dry, the surface should be well rubbed down with fine sandpaper, and all imperfections, such as nail holes and sharp corners, not already provided for, should be carefully filled with beeswax and rubbed off smooth before the second coat of varnish is applied. After a pattern has once been used, it is good practice to again rub it off with very fine sandpaper, and apply another coat of varnish. Many well-made patterns are ruined in the foundry by not being provided with the proper facilities for rapping and drawing. The molder must have some means for attaching his appliances for lifting it out, and, if suitable provision is not made for this purpose, he will screw his lifter in any part of the pattern that is most convenient, and the chances are, that it will split the first time it is used, or badly marred up. Iron plates should be let into all patterns with holes threaded to suit his lifters, and well secured either by screws or rivets, and, if a sufficient number are attached, the molder will respect the pattern and use them. Wood patterns should never be allowed to remain in the foundry; as soon as they are used, they should be taken to the pattern-room, brushed off and placed in such a position for future use that they will not become warped or sprung.

ELECTRIC HAND LANTERN.

A German patent has been granted to A. Friedlander for an electric hand lantern. This consists of a box of hard rubber carrying a small three-candle power incandescent light, together with a reflector and glass protector. The elements in the box, carbon and zinc, produce the current necessary to feed the light. The box is divided into five compartments holding the liquid, and the electrodes are placed in such position that no decomposition occurs when the lantern is not in use. The circuit is closed when the electrodes are dipped in the liquid; the current is stronger and the light brighter if the electrodes are dipped deeper in the liquid; this depth and consequently the brightness of the light can be regulated by means of a button on the outside. The liquid is a combined solution of chloride of zinc, bichromate of soda in water and acid, and the lantern can hold a sufficient supply of this solution to last for about three hours.

TABLES OF GEARS FOR CUTTING STANDARD SCREW-THREADS.

INTRODUCTION.

It may, perhaps, be necessary to state that these tables are the fruit of much experience, and a deep-seated conviction that their want is sorely felt by many. Notwithstanding the vast improvements of modern screw-cutting machinery, much time is still wasted by the most experienced workmen in endeavoring to find wheels to but any particular pitch o. screw, or broken number, in consequence of the various changes to be obtained from the usual set of screw-cutting wheels, most of which begin with a 20-teeth, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140 and 150. This may be considered a full set, inasmuch as any screw may be cut with it. Supposing the 20-wheel to be put on the mandrel, for single changes, without the pinion, the first figure up to 95 will give the number of threads to the inch. A 20 and A 25 will cut 2½; 20 and 30, 3 to the inch, and so on in like ratio. When three figures are on the wheels, however, the first two will indicate the number to the inch; as, 20 and 100 will cut 10; 20 and 110 will cut 11; etc. For many common numbers this will save the trouble of looking to the tables, if a ⅝, ¾, or other coarse pitch. If the book be referred to for the decimal of the ratios required, against it will be found the wheels that will cut it. If the number be required to the foot, then multiply by twelve.

These tables are calculated on the assumption that a pinion of twenty teeth is used, and a driving-screw of two threads to the inch.

Wheels, when affixed to the mandrel, are called mandrel-wheels; those on the screw, screw-wheels; and those intervening, intermediate-wheels. When the mandrel and screw-wheels are connected by one or more wheels directly, they are termed simple wheels. When attached by means of a pinion joined to the intermediate wheel, they are called compound-wheels.

No. I, is a table of simple wheels. The mandrel-wheels are in the first perpendicular column; and the screw-wheels in the top horizontal column. In the spaces where the perpendicular intersects the horizontal, will be found the pitch of the thread which any two wheels will cut.

The remaining tables are of compound wheels. The mandrel-wheels will be found in the first perpendicular column, the intermediate-wheels in the top horizontal column, and the screw-wheels in the bottom column. The pitch of thread

to be cut having been found in the tables, on the left hand the mandrel-wheel will be found, on the top the intermediate wheel, and at the bottom the screw-wheel.

All lathes have not a twenty-teeth pinion, in which case, the following rule will be of use as applying to any other pinion:

Multiply the pitch of thread intended to be cut, by the new pinion, and divide by twenty. Find the wheels in the tables corresponding with the quotient, and use the new pinion instead of the twenty.

In some lathes the mandrel-wheel is a fixture. In these instances, suppose the mandrel-wheel to be the pinion, and attach the mandrel-wheel found in the table to the intermediate-wheel.

To ascertain the ratio of any series of wheels, multiply the whole of the driven wheels togetner, which will give the total number of teeth in the series. Then divide the result by the driving wheels multiplied into each other. The quotient will be the number of times the first wheel will revolve to the last. Suppose a wheel of twenty teeth to be driving a wheel of 100 teeth, to which is attached a wheel of thirty teeth driving a wheel of 150 teeth, and the ratio be required—

$$\frac{100 \times 150}{20 \times 30} = 25 \text{ revolutions.}$$

To find the number of threads a set of wheels will cut, multiply the ratio of the wheels by the pitch of the driving-screw.

To cut double or more threads, divide the mandrel-wheel in as many parts as you require threads, and, as you cut the screw, shift the mandrel-wheel a division, while the screw-wheel remains stationary. This plan will insure equal division and regularity of cutting. In all lathes where the leading screw is two to the inch, and an equal number of threads being cut, if the saddled clutch be thrown out of gear, it will always fall into the right place. If an odd number of threads are being cut, it will fall right every other one. By attending to this rule, running the lathe backward will be avoided, and a screw cut in about half the time.

A difficulty frequently arises in finding the number of threads to the inch or foot when a particular pitch or fractional number has to be matched. This can easily be ascertained by measuring onward, for, if it do not come right in one inch, notice how many there are between any division of rule. In measuring a screw, you discover there are twenty-eight threads in three inches. Consequently, if twenty-eight be divided by three, it gives 9.333 as the pitch. Against that number in the table will be found the wheels to cut it. Suppose a coarse pitch be required, say one thread in 1⅝ inch, the wheels may be found thus: when there is less than one thread to the inch, see how many there are in twelve inches; as, 1.615 in. pitch into 12 in. is 7.384 to the foot. If divided by twelve, we have the dec. .615, against which in the table will be found the wheels.

SCREW WHEELS.

MANDREL WHEELS.	150	140	130	120	110	100	95	90	85	80	75
20	15.	14.	13.	12.	11.	10.	9.5	9.	8.5	8.	7.5
25	12.	11.2	10.4	9.6	8.8	8.	7.6	7.2	6.8	6.4	6.
30	10.	9.333	8.666	8.	7.333	6.666	6.333	6.	5.666	5.333	5.
35	8.571	8.	7.428	6.856	6.284	5.714	5.428	5.142	4.857	4.571	4.285
40	7.5	7.	6.5	6.	5.5	5.	4.75	4.5	4.25	4.	3.75
45	6.666	6.222	5.777	5.333	4.888	4.444	4.222	4.	3.777	3.555	3.333
50	6.	5.6	5.2	4.8	4.4	4.	3.8	3.6	3.4	3.2	3.
55	5.454	5.09	4.727	4.363	4.	3.636	3.454	3.272	3.091	2.909	2.727
60	5.	4.666	4.333	4.	3.666	3.333	3.166	3.	2.833	2.666	2.5
65	4.615	4.307	4.	3 692	3.384	3.077	2.923	2.769	2.615	2.461	2.307
70	4.285	4.	3.714	3.428	3.142	2.857	2.714	2.571	2.428	2.285	2.142
75	4.	3.733	3.466	3.2	2.933	2.666	2.533	2.4	2.266	2.133	2.
80	3.75	3.5	3.25	3.	2.75	2.5	2.375	2.25	2.125	2.	1.875
85	3.529	3.294	3.058	2.823	2.588	2.353	3.235	2.117	2.	1.882	1.764
90	3.333	3.111	2.888	2.666	2.444	2.222	2.111	2.	1.888	1.777	1.666
95	3.157	2.947	2.736	2.526	2.326	2.105	2	1.894	1.789	1.684	1.579
100	3.	2.8	2.6	2.4	2.2	2.	1.9	1.8	1.7	1.6	1.5
110	2.727	2.545	2.363	2.181	2.	1.818	1.727	1.636	1.545	1.454	1.363
120	2.5	2.333	2.166	2.	1.833	1.666	1.583	1.5	1.416	1.333	1.25
130	2.307	2.153	2.	1.846	1.692	1.538	1.461	1.384	1.307	1.230	1.153
140	2.142	2.	1.857	1.714	1.571	1.428	1.357	1.285	1.214	1.142	1.071
150	2.	1.866	1.733	1.6	1.466	1.333	1.266	1.2	1.133	1.066	1.

SCREW WHEELS.

MANDREL WHEELS.	70	65	60	55	50	45	40	35	30	25
20	7.	6.5	6.	5.5	5.	4.5	4.	3.5	3.	2.5
25	5.6	5.2	4.8	4.4	4.	3.6	3.2	2.8	2.4	2.
30	4.666	4.333	4.	3.666	3.333	3.	2.666	2.333	2.	1.666
35	4.	3.714	3.428	3.142	2.857	2.571	2.284	2.	1.714	1.428
40	3.5	3.25	3.	2.75	2.5	2.25	2.	1.75	1.5	1.25
45	3.111	2.888	2.666	2.444	2.222	2.	1.777	1.555	1.333	1.111
50	2.8	2.6	2.4	2.2	2.	1.8	1.6	1.4	1.2	1.
55	2.545	2.363	2.181	2.	1.818	1.636	1.454	1.272	1.091	.909
60	2.333	2.166	2.	1.833	1.666	1.5	1.333	1.166	1.	.833
65	2.153	2.	1.846	1.692	1.538	1.384	1.230	1.076	.923	.769
70	2.	1.857	1.714	1.571	1.428	1.285	1.142	1.	.857	.714
75	1 866	1.733	1.6	1.466	1.333	1.2	1.066	.933	.8	.666
80	1.75	1.625	1.5	1.375	1.25	1.125	1.	.875	.75	.625
85	1.637	1.529	1.411	1.294	1.176	1.058	.941	.818	.705	.588
90	1.555	1.444	1.333	1.222	1.111	1.	.888	.777	.666	.555
95	1.473	1.368	1.263	1.163	1.052	.947	.842	.736	.631	.526
100	1.4	1.3	1.2	1.1	1.	.9	.8	.7	.6	.5
110	1.272	1.181	1.091	1.	.909	.818	.727	.636	.545	.454
120	1.166	1.083	1.	.916	.833	.75	.666	.583	.5	.416
130	1.076	1.	.923	.846	.769	.692	.615	.538	.461	.384
140	1.	.928	.857	.785	.714	.642	.571	.5	.428	.357
150	.933	.866	.8	.733	.666	.6	.533	.466	.4	.333

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	140	130	130	120	120	120	110	110	110	110	100
20	105.	97.5	91.	90.	84.	78	82.5	77.	71.5	66.	75.
25	84.	78.	72.8	72.	67.2	62.4	66.	61.6	57.2	52.8	60.
30	70.	65.	60.666	60.	56.	52.	55.	51.333	47.666	44.	50.
35	60.	55.714	52.	51.428	48.	44.571	47.142	44.	40.857	37.714	42.857
40	52.5	48.75	45.5	45.	42.	39.	41.25	38.5	35.75	33.	37.5
45	46.666	43.333	40.444	40.	37.333	34.666	36.666	34.222	31.777	29.333	33.333
50	42.	39.	36.4	36.	33.6	31.2	33.	30.8	28.6	26.4	30.
55	38.181	35.454	33.091	32.727	30.545	28.303	30.	28.	26.	24.	27.272
60	35.	32.5	30.333	30.	28.	26.	27.5	25.666	23.833	22.	25.
65	32.307	30.	28.	27.692	25.846	24.	25.284	23.692	22.	20.307	23.076
70	30.	27.857	26.	25.714	24.	22 285	23.571	22.	20.428	18.857	21.428
75	28.	26.	24.266	24.	22.4	20.8	22.	20.533	19.066	17.6	20.
80	26.25	24.375	22.75	22.5	21.	19.5	20.625	19.25	17.875	16.5	18.75
85	24.705	22.941	21.41	21.176	19.764	18.352	19 411	18.117	16.823	15.529	17.647
90	23.333	21.666	20.222	20.	18.666	17.333	18.333	17.111	15.888	14.666	16.666
95	22.105	20.526	19.156	18.946	17.684	16.421	17.368	16.21	15.062	13.894	15.789
100	21.	19.5	18.2	18.	16.8	15.6	16.5	15.4	14.3	13.2	15.
110	19.091	17.727	16.545	16.363	15.272	14.181	15.	14.	13.	12.	13.636
120	17.5	16.25	15.166	15.	14.	13.	13.75	12.833	11.916	11.	12.5
130	16.154	15.	14.	13.846	12.933	12.	12.642	11.846	11.	10.153	11.538
140	15.	13.928	13.	12.857	12.	11.142	11.785	11.	10.214	9.428	10.714
SCREW WHEELS	150	150	140	150	140	130	150	140	130	120	150

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	100	110	100	100	95	95	95	95	95	95
20	70.	65.	60.	55.	71.25	66.5	61.75	57.	52.25	47.5
25	56.	52.	48.	44.	57.	53.2	49.4	45.6	41.8	38.
30	46.666	43.333	40.	36.666	47.5	44.333	41.166	38.	34.833	31.666
35	40.	37.142	34.285	31.428	40.714	38.	35.284	32.57	29.856	27.142
40	35.	32.5	30.	27.5	35.625	33.25	30.875	28.5	26.125	23 75
45	31.111	28.888	26.666	24.444	31.666	29.555	27.444	25.333	23.222	21.111
50	28.	26.	24.	22.	28.5	26.6	24.7	22.8	20.9	19.
55	25.454	23.636	21.818	20.	25.908	24.181	22.454	20.727	19.	17.272
60	23.333	21.666	20.	18.333	23.75	22.166	20.583	19.	17.416	15.833
65	21.538	20.	18.461	16.923	21.922	20.461	19.	17.538	16.076	14.615
70	20.	18.571	17.142	15.714	20.357	19.	17.642	16.384	14.928	13.570
75	18.633	17.333	16.	14.666	19.	17.733	16.466	15.2	13.932	12.666
80	17.5	16.25	15.	13.75	17.812	16.625	15.437	14.25	13.062	11.875
85	16.470	15.294	14.117	12.941	16.764	15.647	14.528	13.41	12.294	11.176
90	15.555	14.444	13.333	12.222	15.833	14.777	13.722	12.666	11.611	10.555
95	14.736	13.688	12.631	11.578	15.	14.	13.	12.	11.	10.
100	14.	13.	12.	11.	14.25	13.3	12.35	11.4	10.45	9.5
110	12.727	11.818	10.909	10.	12.954	12.091	11.227	10.363	9.5	8.636
120	11.666	10.833	10.	9.166	11.875	11.083	10.291	9.5	8.708	7.916
130	10.769	10.	9.230	8.461	10.961	10.230	9.5	8.769	8.038	7.307
140	10.	9.285	8.571	7.857	10.178	9.5	8.821	8.142	7.464	6.785
SCREW WHEELS.	140	130	120	110	150	140	130	120	110	100

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	90	90	90	90	90	90	90	85	85	85	85
20	67.5	63.	58.5	54.	49.5	45.	42.75	63.75	59.5	55.25	51.
25	54.	50.4	46.8	43.2	39.6	36.	34.2	51.	47.6	44.2	40.8
30	45.	42.	39.	36.	33.	30.	28.5	42.5	39 666	36.833	34.
35	38.571	36.	33.428	30.857	28.282	25.714	24.428	36.428	34.	31.571	29.142
40	33.75	31.5	29.25	27.	24.75	22.5	21.375	31.857	29.75	27.625	25.5
45	30.	28.	26.	24.	22.	20.	19.	28.333	26.444	23.555	22.666
50	27.	25.2	23.4	21.6	19.8	18.	17.1	25.	23.8	22.1	20.4
55	24.545	22.909	21.272	19.636	18.	16.363	15.545	23.181	21.636	20.091	18.545
60	22.5	21.	19.5	18.	16.5	15.	14.25	21.25	19.833	18.416	17.
65	20.769	19.384	18.	16.615	15.238	13.846	13.153	19.615	18.307	17.	15.692
70	19.285	18.	15.714	15.428	14.141	12.847	12.214	18.214	17.	15.785	14.571
75	18.	16.8	15.6	14.4	13.2	12.	11.4	17.	15.866	14.733	13.6
80	16.875	15.75	14.625	13.5	12.375	11.25	10.687	15.937	14.875	13.812	12.75
85	15.882	14.823	13.764	12.705	11.647	10.588	10.058	15.	14.	13.	12.
90	15.	14.	1[illegible]	12.	11.	10.	9.5	14.166	13.222	12.277	11.333
95	14.21	13.26[illegible]	12.315	11.363	10.421	9.468	9.	13.421	12.526	11.631	10.737
100	13.5	12.6	11.7	10.8	9.9	9.	8.55	12.75	11.9	11.05	10.2
110	12.272	11.454	10.636	9.818	9.	8.181	7.772	11.59	10.818	10.045	9.272
120	11.25	10.5	9.75	9.	8.25	7.5	7.125	10.625	9.916	9.208	8.5
130	10.384	9.692	9.	8.307	7.619	6.923	6.576	9.807	9.153	8.5	7.846
140	9.642	9.	8.357	7.714	7.071	6.428	6.107	9.107	8.5	7.892	7.285
SCREW WHEELS.	150	140	130	120	110	100	95	150	140	130	120

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	85	85	85	85	80	80	80	80	80	80
20	46.75	42.5	40.375	38.25	60.	56.	52.	48.	44.	40.
25	37.4	34.	32.3	30.6	48.	44.8	41.6	38.4	35.2	32.
30	31.166	28.333	26.916	25.5	40.	37.333	34.666	32.	29.333	26.666
35	26.714	24.285	23.071	21.857	34.285	32.	29.714	27.428	25.142	22.857
40	23.375	21.25	20.187	19.125	30.	28.	26.	24.	22.	20.
45	20.777	18.8	17.944	17.	26.666	24.888	23.111	21.333	19.555	17.777
50	18.7	17.	16.150	15.3	24.	22.4	20.8	19.2	17.6	16.
55	17.	15.454	14.681	13.909	21.818	20.363	18.981	17.454	16.	14.545
60	15.583	14.166	13.458	12.75	20.	18.666	17.333	16.	14.666	13.333
65	14.384	13.076	12.423	11.769	18.461	17.23	16.	14.769	13.538	12.307
70	13.357	12.142	11.536	10.928	17.142	16.	14.857	13.714	12.571	11.428
75	12.466	11.333	10.766	10.2	16.	14.933	13.866	12.8	11.733	10.666
80	11.687	10.625	10.093	9.562	15.	14.	13.	12.	11.	10.
85	11.	10.	9.5	9.	14.117	13.176	12.235	11.294	10.353	9.411
90	10.388	9.444	8.972	8.5	13.333	12.444	11.555	10.666	9.777	8.888
95	9.842	8.942	8.5	8.053	12.631	11.079	10.942	10.105	9.268	8.421
100	9.35	8.5	8.075	7.65	12.	11.2	10.4	9.6	8.8	8.
110	8.5	7.727	7.342	6.954	10.909	10.181	9.495	8.727	8.	7.272
120	7.791	7.083	6.729	6.375	10.	9.333	8.666	8.	7.333	6.666
130	7.192	6.538	6.211	5.884	9.23	8.615	8.	7.384	6.769	6.153
140	6.678	6.071	5.768	5.464	8.571	8.	7.428	6.857	6.285	5.714
SCREW WHEELS.	110	100	95	90	150	140	130	120	110	100

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	80	80	80	75	75	75	75	75	75	75	75
20	38.	36.	34.	56.25	52.5	48.75	45.	41.25	37.5	35.625	33.75
25	30.4	28.8	27.2	45.	42.	39.	36.	33.	30.	28.5	27.
30	25.333	24.	22.666	37.5	35	32.5	30.	27.5	25.	23.75	22.5
35	21.714	20.571	19.428	32.142	30	27.856	25.714	23.571	21.428	20.356	19.285
40	19.	18.	17.	28.125	26.25	24.375	22.5	20.625	18.75	17.812	16.875
45	16.8	16.	15.111	25.	23.333	21.666	20.	18.333	16.666	15.833	15.
50	15.2	14.4	13.6	22.5	21.	19.5	18.	16.5	15.	14.25	13.5
55	13.818	13.091	12.363	20.454	19.091	17.727	16.362	15.	13.636	12.955	12.272
60	12.666	12.	11.333	18.75	17.5	16.25	15.	13.75	12.5	11.875	11.25
65	11.692	11.876	10.461	17.307	16.153	15.	13.846	12.692	11.537	10.962	10.384
70	10.857	10.285	9.714	16.071	15.	13.928	12.857	11.785	10.714	10.178	9.642
75	10.133	9.6	9.066	15.	14.	13.	12.	11.	10.	9.5	9.
80	9.5	9.	8.5	14.062	13.125	12.187	11.25	10.312	9.375	8.96	8.437
85	8.941	8.47	8.	13.235	12.352	11.475	10.588	9.758	8.823	8.382	7.941
90	8.4	8.	7.555	12.5	11.666	10.833	10.	9.166	8.333	7.916	7.5
95	8.	7.579	7.157	11.842	11.052	10.263	9.472	8.684	7.894	7.5	7.152
100	7.6	7.2	6.8	11.25	10.5	9.75	9.	8.250	7.5	7.125	6.75
110	6.909	6.545	6.181	10.227	9.545	8.863	8.181	7.5	6.818	6.477	6.136
120	6.333	6.	5.666	9.375	8.75	8.125	7.5	6.875	6.25	5.937	5.625
130	5.846	5.938	5.230	8.653	8.076	7.5	6.923	6.346	5.768	5.481	5.192
SCREW WHEELS.	95	90	85	150	140	130	120	110	100	95	90

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	75	75	70	70	70	70	70	70	70	70
20	31.875	30.	52.5	49.	45.5	42.	38.5	35.	33.25	31.5
25	25.5	24.	42.	39.2	36.4	33.6	30.8	28.	26.6	25.2
30	21.25	20.	35.	32.666	30.333	28.	25.666	23.333	22.166	21.
35	18.214	17.142	30.	28.	26.	24.	22.	20.	19.	18.
40	15.937	15.	26.25	24.5	22.75	21.	19.25	17.5	16.625	15.75
45	14.166	13.333	23.333	21.777	20.222	18.666	17.111	15.555	14.776	14.
50	12.75	12.	21.	19.6	18.2	16.8	15.4	14.	13.3	12.6
55	11.59	10.909	19.090	17.816	16.545	15.272	14.	12.727	12.091	11.454
60	10.625	10.	17.5	16.333	15.166	14.	12.833	11.666	11.083	10.5
65	9.807	9.237	16.153	15.076	14.	12.923	11.714	10.769	10.237	9.692
70	9.107	8.571	15.	14.	13.	12.	11.	10.	9.5	9.
75	8.5	8.	14.	13.066	12.133	11.2	10.266	9.32	8.866	8.4
80	7.968	7.5	13.125	12.250	11.375	10.5	9.625	8.75	8.312	7.875
85	7.5	7.058	12.352	11.561	10.758	9.882	9.058	8.235	7.823	7.411
90	7.083	6.666	11.666	10.888	10.111	9.333	8.555	7.777	7.388	7.
95	6.71	6.315	11.052	10.312	9.578	8.842	8.152	7.368	7.	6.603
100	6.375	6.	10.5	9.8	9.1	8.4	7.7	7.	6.650	6.3
110	5.795	5.454	9.545	8.908	8.272	7.636	7.	6.363	6.045	5.727
120	5.312	5.	8.75	8.166	7.583	7.	6.416	5.833	5.541	5.25
130	4.903	4.618	8.076	7.538	7.	6.461	5.857	5.384	5.118	4.846
SCREW WHEELS.	85	80	150	140	130	120	110	100	95	90

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	70	70	70	65	65	65	65	65	65	65	65
20	29.75	28.	26.25	48.75	45.5	42.25	39.	35.75	32.5	30.875	29.25
25	23.8	22.4	21.	39.	36.4	33.8	31.2	28.6	26.	32.7	23.4
30	19.833	18.666	17.5	32.5	30.333	28.166	26.	23.833	21.666	20.580	19.5
35	17.	16.	15.	27.857	26.	24.142	22.285	20.428	18.571	17.642	16.714
40	14.875	14.	13.125	24.375	22.750	21.125	19.5	17.875	16.25	15.437	14.625
45	13.222	12.444	11.666	21.666	20.222	18.777	17.333	15.888	14.444	13.722	13.
50	11.9	11.2	10.5	19.5	18.2	16.9	15.6	14.3	13.	12.35	11.7
55	10.818	10.181	9.545	17.727	16.545	15.363	14.181	13.	11.818	11.227	10.636
60	9.916	9.333	8.75	16.25	15.166	14.083	13.	11.916	10.833	10.291	9.75
65	9.153	8.615	8.076	15.	14.	13.	12.	11.	10.	9.5	9.
70	8.5	8.	7.5	13.928	13.	12.071	11.142	10.214	9.285	8.821	8.357
75	7.933	7.466	7.	13.	12.133	11.266	10.4	9.533	8.666	8.233	7.8
80	7.437	7.	6.562	12.187	11.375	10.562	9.75	8.937	8.125	7.718	7.312
85	7.	6.588	6.176	11.475	10.758	9.941	9.176	8.411	7.647	7.264	6.882
90	6.611	6.222	5.833	10.833	10.111	9.388	8.666	7.944	7.222	6.861	6.5
95	6.263	5.894	5.526	10.263	9.578	8.894	8.215	7.526	6.842	6.5	6.157
100	5.95	5.6	5.25	9.75	9.1	8.45	7.8	7.15	6.5	6.175	5.85
110	5.409	5.090	4.772	8.863	8.272	7.681	7.090	6.5	5.909	5.613	5.318
120	4.958	4.666	4.375	8.125	7.583	7.041	6.5	5.958	5.416	5.145	4.875
130	4.576	4.307	4.038	7.5	7.	6.5	6.	5.5	5.	4.75	4.5
SCREW WHEELS.	85	80	75	150	140	130	120	110	100	95	90

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	65	65	65	65	60	60	60	60	60	60
20	27.624	26.	24.375	22.75	45.	42.	39.	36.	33.	30.
25	22.1	20.8	19.5	18.2	36.	33.6	31.2	28.8	26.4	24.
30	18.416	17.333	16.25	15.166	30.	28.	26.	24.	22.	20.
35	15.785	14.857	13.928	13.	25.714	24.	22.284	20.571	18.857	17.142
40	13.812	13.	12.187	11.375	22.5	21.	19.5	18.	16.5	15.
45	12.277	11.555	10.833	10.111	20.	18.666	17.333	16.	14.666	13.333
50	11.05	10.4	9.75	9.1	18.	16.8	15.6	14.4	13.2	12.
55	10.044	9.454	8.863	8.272	16.363	15.272	14.181	13.091	12.	10.909
60	9.208	8.666	8.125	7.583	15.	14.	13.	12.	11.	10.
65	8.5	8.	7.5	7.	13.846	12.923	12.	11.076	10.153	9.237
70	7.892	7.428	6.964	6.5	12.857	12.	11.142	10.285	9.428	8.571
75	7.306	6.933	6.5	6.066	12.	11.2	10.4	9.6	8.8	8.
80	6.906	6.5	6.093	5.687	11.25	10.5	9.75	9.	8.25	7.5
85	6.5	6.117	5.737	5.352	10.588	9.882	9.176	8.475	7.764	7.058
90	6.138	5.777	5.416	5.055	10.	9.333	8.666	8.	7.333	6.666
95	5.815	5.473	5.131	4.789	9.473	8.842	8.215	7.578	6.947	6.315
100	5.525	5.2	4.875	4.55	9.	8.4	7.8	7.2	6.6	6.
110	5.022	4.727	4.431	4.136	8.181	7.636	7.099	6.545	6.	5.454
120	4.604	4.333	4.062	3.781	7.5	7.	6.5	6.	5.5	5.
130	4.25	4.	3.75	3.5	6.923	6.461	6.	5.538	5.076	4.618
SCREW WHEELS.	85	80	75	70	150	140	130	120	110	100

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	60	60	60	60	60	60	60	55	55	55	55
20	28.5	27.	25.5	24.	22.5	21.	19.5	41.25	38.5	35.75	33.
25	22.8	21.6	20.4	19.2	18.	16.8	15.6	33.	30.8	28.6	26.4
30	19.	18.	17.	16.	15.	14.	13.	27.5	25.666	23.833	22.
35	16.285	15.428	14.571	13.714	12.857	12.	11.142	23.571	22.	20.428	18.857
40	14.25	13.5	12.75	12.	11.25	10.5	9.75	20.625	19.25	17.875	16.5
45	12.666	12.	11.333	10.666	10.	9.333	8.666	18.333	17.111	15.888	14.666
50	11.4	10.8	10.2	9.6	9.	8.4	7.8	16.5	15.4	14.3	13.2
55	10.363	9.818	9.272	8.727	8.181	7.636	7.091	15	14.	13.	12.
60	9.5	9.	8.5	8.	7.5	7.	6.5	13.75	12.833	11.916	11.
65	8.769	8.373	7.846	7.384	6.923	6.461	6.	12.692	11.846	11.	10.152
70	8.142	7.714	7.285	6.857	6.428	6.	5.571	11.785	11.	10.214	9.428
75	7.6	7.2	6.8	6.4	6.	5.6	5.2	11.	10.266	9.533	8.8
80	7.125	6.75	6.375	6.	5.625	5.25	4.875	10.312	9.625	8.937	8.25
85	6.758	6.352	6.	5.647	5.294	4.941	4.588	9.758	9.058	8.411	7.764
90	6.333	6.	5.666	5.333	5.	4.666	4.333	9.166	8.555	7.944	7.333
95	6.	5.684	5.368	5.052	4.736	4.421	4.152	8.684	8.152	7.526	6.947
100	5.7	5.4	5.1	4.8	4.5	4.2	3.9	8.25	7.7	7.150	6.6
110	5.181	4.909	4.636	4.363	4.091	3.818	3.545	7.5	7.	6.5	6.
120	4.75	4.5	4.25	4.	3.75	3.5	3.25	6.875	6.416	5.958	5.5
130	4.384	4.186	3.923	3.692	3.461	3.230	3.	6.346	5.923	5.5	5.076
SCREW WHEELS.	95	90	85	80	75	70	65	150	140	130	120

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	55	55	55	55	55	55	55	55	55	55
20	30.25	27.5	26.125	24.75	23.375	22.	20.625	19.25	17.875	16.5
25	24.2	22.	20.9	19.8	18.7	17.6	16.5	15.4	14.3	13.2
30	20.166	18.333	17.416	16.5	15.583	14.666	13.75	12.833	11.916	11.
35	17.285	15.714	14.928	14.142	13.357	12.571	11.785	11.	10.214	9.428
40	15.125	13.75	13.062	12.375	11.687	11.	10.312	9.625	8.937	8.25
45	13.444	12.222	11.611	11.	10.388	9.777	9.166	8.555	7.944	7.333
50	12.1	11.	10.45	9.9	9.35	8.8	8.25	7.7	7.15	6.6
55	11.	10.	9.5	9.	8.5	8.	7.5	7.	6.5	6.
60	10.083	9.166	8.708	8.25	7.791	7.333	6.875	6.416	5.958	5.5
65	9.376	8.461	8.038	7.615	7.192	6.769	6.346	5.923	5.5	5.075
70	8.642	7.857	7.464	7.071	6.678	6.285	5.892	5.5	5.107	4.714
75	8.066	7.333	6.966	6.6	6.233	5.866	5.5	5.133	4.766	4.4
80	7.562	6.875	6.531	6.185	5.843	5.5	5.156	4.812	4.468	4.125
85	7.117	6.475	6.147	5.823	5.5	5.176	4.876	4.529	4.205	3.882
90	6.722	6.111	5.805	5.5	5.194	4.888	4.583	4.277	3.972	3.666
95	6.368	5.789	5.5	5.215	4.921	4.631	4.342	4.052	3.763	3.473
100	6.05	5.5	5.225	4.95	4.675	4.4	4.125	3.85	3.575	3.3
110	5.5	5.	4.75	4.5	4.25	4.	3.75	3.5	3.25	3.
120	5.041	4.583	4.354	4.125	3.895	3.666	3.437	3.208	2.979	2.75
130	4.688	4.230	4.019	3.807	3.596	3.384	3.173	2.961	2.75	2.537
SCREW WHEELS.	110	100	95	90	85	80	75	70	65	60

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	50	50	50	50	50	50	50	50	50	50	50
20	37.5	35.	32.5	30.	27.5	25.	23.75	22.5	21.25	20.	18.75
25	30.	28.	26.	24.	22.	20.	19.	18.	17.	16.	15.
30	25.	23.333	21.666	20.	18.333	16.666	15.833	15.	14.166	13.333	12.5
35	21.428	20.	18.571	17.142	15.714	14.285	13.571	12.857	12.142	11.428	10.714
40	18.75	17.5	16.25	15.	13.75	12.5	11.875	11.25	10.625	10.	9.375
45	16.666	15.555	14.444	13.333	12.222	11.111	10.555	10.	9.444	8.888	8.333
50	15.	14.	13.	12.	11.	10.	9.5	9.	8.5	8.	7.5
55	13.636	12.727	11.818	10.909	10.	9.091	8.636	8.181	7.727	7.272	6.818
60	12.5	11.666	10.833	10.	9.166	8.333	7.916	7.5	7.083	6.666	6.25
65	11.538	10.769	10.	9.237	8.461	7.692	7.376	6.923	6.538	6.153	5.769
70	10.714	10.	9.285	8.571	7.857	7.142	6.785	6.428	6.071	5.714	5.357
75	10.	9.333	8.666	8.	7.333	6.666	6.333	6.	5.658	5.333	5.
80	9.375	8.75	8.125	7.5	6.875	6.25	5.937	5.625	5.312	5.	4.687
85	8.823	8.235	7.647	7.058	6.475	5.882	5.588	5.294	5.	4.758	4.411
90	8.333	7.777	7.222	6.666	6.111	5.555	5.277	5.	4.722	4.444	4.166
95	7.894	7.368	6.842	6.315	5.789	5.263	5.	4.736	4.473	4.215	3.947
100	7.5	7.	6.5	6.	5.5	5.	4.75	4.5	4.25	4.	3.750
110	6.818	6.363	5.909	5.454	5.	4.545	4.318	4.091	3.863	3.636	3.409
120	6.25	5.833	5.417	5.	4.583	4.166	3.958	3.75	3.541	3.333	3.125
130	5.769	5.384	5.	4.618	4.230	3.846	3.688	3.461	3.269	3.076	2.884
SCREW WHEELS.	150	140	130	120	110	100	95	90	85	80	75

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	50	50	50	50	45	45	45	45	45	45
20	17.5	16.25	15.	13.75	33.75	31.5	29.25	27.	24.75	22.5
25	14.	13.	12.	11.	27.	25.2	23.4	21.6	19.8	18.
30	11.666	10.833	10.	9.166	22.5	21.	19.5	18.	16.5	15.
35	10.	9.285	8.571	7.857	19.285	18.	16.714	15.428	14.142	12.857
40	8.75	8.125	7.5	6.875	16.875	15.75	14.625	13.5	12.375	11.25
45	7.777	7.222	6.666	6.111	15.	14.	13.	12.	11.	10.
50	7.	6.5	6.	5.5	13.5	12.6	11.7	10.8	9.9	9.
55	6.363	5.909	5.454	5.	12.272	11.454	10.636	9.818	9.	8.181
60	5.833	5.416	5.	4.583	11.25	10.5	9.75	9.	8.25	7.5
65	5.384	5.	4.615	4.238	10.384	9.692	9.	8.376	7.615	6.92
70	5.	4.642	4.285	3.928	9.642	9.	8.357	7.714	7.071	6.428
75	4.666	4.333	4.	3.666	9.	8.4	7.710	7.2	6.6	6.
80	4.375	4.062	3.75	3.437	8.437	7.875	7.312	6.75	6.187	5.625
85	4.117	3.823	3.529	3.235	7.941	7.411	6.882	6.352	5.823	5.294
90	3.888	3.611	3.333	3.055	7.5	7.	6.5	6.	5.5	5.
95	3.684	3.422	3.263	2.894	7.152	6.031	6.157	5.684	5.215	4.736
100	3.5	3.25	3.	2.75	6.75	6.3	5.85	5.4	4.95	4.5
110	3.181	2.954	2.727	2.5	6.136	5.737	5.318	4.909	4.5	4.091
120	2.916	2.708	2.5	2.291	5.625	5.25	4.875	4.5	4.125	3.75
130	2.692	2.5	2.307	2.119	5.192	4.846	4.5	4.188	3.807	3.46
SCREW WHEELS.	70	65	60	55	150	140	130	120	110	100

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	45	45	45	45	45	45	45	45	45	45	40
20	21.375	20.25	19.125	18.	16.875	15.75	14.625	13.5	12.375	11.25	30.
25	17.1	16.2	15.3	14.4	13.5	12.6	11.7	10.8	9.9	9.	24.
30	14.25	13.5	12.75	12.	11.25	10.5	9.75	9.	8.25	7.5	20.
35	12.214	11.571	10.928	10.285	9.642	9.	8.357	7.711	7.071	6.428	17.142
40	10.687	10.125	9.562	9.	8.437	7.875	7.312	6.75	6.187	5.625	15.
45	9.5	9.	8.5	8.	7.5	7.	6.5	6.	5.5	5.	13.333
50	8.55	8.1	7.65	7.2	6.75	6.3	5.85	5.4	4.95	4.5	12.
55	7.772	7.363	6.954	6.545	6.136	5.727	5.318	4.909	4.5	4.091	10.909
60	7.125	6.75	6.375	6.	5.625	5.25	4.875	4.5	4.125	3.75	10.
65	6.576	6.237	5.884	5.536	5.192	4.846	4.5	4.153	3.807	3.461	9.237
70	6.107	5.785	5.464	5.142	4.821	4.5	4.178	3.856	3.535	3.214	8.571
75	5.7	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3.	8.
80	5.343	5.062	4.781	4.5	4.218	3.937	3.656	3.375	3.093	2.812	7.5
85	5.029	4.764	4.5	4.235	3.97	3.758	3.441	3.176	2.911	2.647	7.058
90	4.75	4.5	4.25	4.	3.75	3.5	3.25	3.	2.75	2.5	6.666
95	4.5	4.263	4.026	3.789	3.576	3.315	3.078	2.842	2.607	2.368	6.315
100	4.275	4.05	3.825	3.6	3.375	3.15	2.925	2.7	2.475	2.25	6.
110	3.886	3.681	3.477	3.272	3.068	2.863	2.659	2.454	2.25	2.045	5.454
120	3.562	3.375	3.187	3.	2.812	2.625	2.437	2.25	2.062	1.875	5.
130	3.288	3.118	2.942	2.768	2.596	2.423	2.25	2.076	1.903	1.730	4.618
SCREW WHEELS.	95	90	85	80	75	70	65	60	55	50	150

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	40	40	40	40	40	40	40	40	40	40
20	28.	26.	24.	22.	20.	19.	18.	17.	16.	15.
25	22.4	20.8	19.2	17.6	16.	15.2	14.4	13.6	12.8	11.
30	18.666	17.333	16.	14.666	13.333	12.666	12.	11.333	10.666	10.
35	16.	14.857	13.714	12.571	11.428	10.857	10.285	9.714	9.142	8.571
40	14.	13.	12.	11.	10.	9.5	9.	8.5	8.	7.5
45	12.444	11.555	10.666	9.777	8.888	8.444	8.	7.555	7.111	6.666
50	11.2	10.4	9.6	8.8	8.	7.6	7.2	6.8	6.4	6.
55	10.181	9.454	8.727	8.	7.272	6.909	6.545	6.181	5.818	5.454
60	9.333	8.666	8.	7.333	6.666	6.333	6.	5.666	5.333	5.
65	8.615	8.	7.384	6.769	6.153	5.846	5.538	5.237	4.928	4.615
70	8.	7.428	6.857	6.285	5.714	5.428	5.142	4.857	4.571	4.285
75	7.466	6.933	6.4	5.866	5.333	5.066	4.8	4.533	4.266	4.
80	7.	6.5	6.	5.5	5.	4.75	4.5	4.25	4.	3.75
85	6.588	6.117	5.647	5.176	4.758	4.475	4.235	4.	3.764	3.529
90	6.222	5.777	5.333	4.888	4.444	4.222	4.	3.777	3.555	3.333
95	5.894	5.473	5.055	4.631	4.215	4.	3.789	3.578	3.368	3.157
100	5.6	5.2	4.8	4.4	4.	3.8	3.6	3.4	3.2	3.
110	5.091	4.727	4.363	4.	3.636	3.454	3.272	3.091	2.909	2.727
120	4.666	4.333	4.	3.666	3.333	3.166	3.	2.833	2.666	2.5
130	4.307	4.	3.692	3.384	3.076	2.923	2.769	2.618	2.464	2.307
SCREW WHEELS.	140	130	120	110	100	95	90	85	80	75

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	40	40	40	40	40	40	35	35	35	35	35
20	14.	13.	12.	11.	10.	9.	26.25	24.5	22.75	21.	19.25
25	11.2	10.4	9.6	8.8	8.	7.2	21.	19.6	18.2	16.8	15.4
30	9.333	8.666	8.	7.333	6.666	6.	17.5	16.333	15.166	14.	12.833
35	8.	7.428	6.857	6.285	5.714	5.142	15.	14.	13.	12.	11.
40	7.	6.5	6.	5.5	5.	4.5	13.125	12.25	11.375	10.5	9.625
45	6.222	5.777	5.333	4.888	4.444	4.	11.666	10.888	10.111	9.333	8.555
50	5.6	5.2	4.8	4.4	4.	3.6	10.5	9.8	9.1	8.4	7.7
55	5.091	4.725	4.363	4.	3.636	3.272	9.545	8.909	8.272	7.636	7.
60	4.666	4.333	4.	3.666	3.333	3.	8.75	8.166	7.583	7.	6.416
65	4.307	4.	3.692	3.384	3.076	2.769	8.076	7.538	7.	6.461	5.923
70	4.	3.714	3.428	3.142	2.857	2.571	7.5	7.	6.5	6.	5.5
75	3.733	3.466	3.2	2.933	2.666	2.4	7.	6.533	6.066	5.6	5.133
80	3.5	3.25	3.	2.75	2.5	2.25	6.562	6.125	5.687	5.25	4.812
85	3.294	3.058	2.823	2.588	2.352	2.177	6.176	5.764	5.352	4.941	4.529
90	3.111	2.888	2.666	2.444	2.222	2.	5.833	5.444	5.055	4.666	4.277
95	2.947	2.736	2.526	2.317	2.105	1.894	5.526	5.157	4.789	4.421	4.052
100	2.8	2.6	2.4	2.2	2.	1.8	5.250	4.9	4.550	4.2	3.85
110	2.545	2.363	2.181	2.	1.818	1.636	4.772	4.454	4.136	3.818	3.5
120	2.333	2.166	2.	1.833	1.666	1.5	4.375	4.083	3.769	3.5	3.208
130	2.153	2.	1.846	1.692	1.538	1.384	4.038	3.769	3.5	3.230	2.961
SCREW WHEELS.	70	65	60	55	50	45	150	140	130	120	110

PINION 20.

INTERMDEIATE WHEELS.

MANDREL WHEELS.	35	35	35	35	35	35	35	35	35	35
20	17.5	16.625	15.75	14.875	14.	13.125	12.25	11.375	10.5	9.625
25	14.	13.3	12.6	11.9	11.2	10.5	9.8	9.1	8.4	7.7
30	11.666	11.083	10.5	9.916	9.333	8.75	8.166	7.583	7.	6.416
35	10.	9.5	9.	8.5	8.	7.5	7.	6.5	6.	5.5
40	8.75	8.312	7.875	7.437	7.	6.562	6.125	5.687	5.25	4.812
45	7.777	7.388	7.	6.611	6.222	5.833	5.444	5.055	4.666	4.277
50	7.	6.65	6.3	5.95	5.6	5.25	4.9	4.55	4.2	3.85
55	6.363	6.045	5.727	5.409	5.091	4.772	4.454	4.136	3.818	3.318
60	5.833	5.541	5.25	4.958	4.666	4.375	4.083	3.791	3.5	3.208
65	5.384	5.118	4.846	4.577	4.307	4.038	3.769	3.5	3.231	2.961
70	5.	4.75	4.5	4.25	4.	3.75	3.5	3.25	3.	2.75
75	4.666	4.433	4.2	3.966	3.733	3.5	3.266	3.033	2.8	2.566
80	4.375	4.156	3.937	3.718	3.5	3.281	3.062	2.843	2.625	2 406
85	4.117	3.911	3.758	3.5	3.294	3.088	2.882	2.676	2.47	2.264
90	3.888	3.694	3.5	3.305	3.111	2.916	2.722	2.527	2.333	2.138
95	3.684	3.5	3.315	3.131	2.947	2.763	2 578	2.394	2.21	2.026
100	3.5	3.325	3.15	2 975	2.8	2.625	2.45	2.275	2.1	1.923
110	3.181	3 022	2.863	2.704	2.545	2.386	2.227	2.068	1.909	1.659
120	2.916	2.770	2.625	2.479	2.333	2.187	2.041	1.895	1.75	1.604
130	2.692	2.559	2.423	2.288	2.153	2.019	1.884	1.75	1.5	1.48
SCREW WHEELS.	100	95	90	85	80	75	70	65	60	55

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	35	35	35	30	30	30	30	30	30	30	30
20	8.75	7.875	7.	22.5	21.	19.5	18.	16.5	15.	14.25	13.5
25	7.	6.3	5.6	18.	16.8	15.6	14.4	13.2	12.	11.4	10.8
30	5.833	5.25	4.666	15.	14.	13.	12.	11.	10.	9.5	9.
35	5.	4.5	4.	12.857	12.	11.142	10.284	9.428	8.571	8.142	7.714
40	4.375	3.937	3.5	11.25	10.5	9.75	9.	8.25	7.5	7.125	6.75
45	3.888	3.5	3.111	10.	9.333	8.666	8.	7.333	6.666	6.333	6.
50	3.5	3.15	2.8	9.	8.4	7.8	7.2	6.6	6.	5.7	5.4
55	3.181	2.863	2.545	8.181	7.636	7.091	6.545	6.	5.454	5.181	4.909
60	2.916	2.625	2.333	7.5	7.	6.5	6.	5.5	5.	4.75	4.5
65	2.692	2.423	2.153	6.923	6.461	6.	5.538	5.077	4.615	4.23	4.154
70	2.5	2.25	2.	6.428	6.	5.571	5.142	4.714	4.285	4.071	3.857
75	2.333	2.1	1.866	6.	5.6	5.2	4.8	4.4	4.	3.8	3.6
80	2.187	1.968	1.75	5.625	5.25	4.875	4.5	4.125	3.75	3.562	3.375
85	2.058	1.879	1.647	5.294	4.941	4.588	4.235	3.882	3.529	3.353	3.176
90	1.944	1.75	1.555	5.	4.666	4.333	4.	3.666	3.333	3.166	3.
95	1.842	1.657	1.473	4.737	4.421	4.105	3.789	3.473	3.157	3.	2.842
100	1.75	1.575	1.4	4.5	4.2	3.9	3.6	3.3	3.	2.85	2.7
110	1.590	1.431	1.272	4.091	3.818	3.545	3.272	3.	2.727	2.590	2.454
120	1.458	1.312	1.166	3.75	3.5	3.25	3.	2.75	2.5	2.375	2.25
130	1.346	1.211	1.076	3.461	3.230	3.	2.769	2.538	2.507	2.115	2.077
SCREW WHEELS.	50	45	40	150	140	130	120	110	100	95	90

PINION 20.

INTERMEDIATE WHEELS.

MANDREL WHEELS.	30	30	30	30	30	30	30	30	30	30
20	12.75	12.	11.25	10.5	9.75	9.	8.25	7.5	6.75	6.
25	10.2	9.6	9.	8.4	7.8	7.2	6.6	6.	5.4	4.8
30	8.5	8.	7.5	7.	6.5	6.	5.5	5.	4.5	4.
35	7.284	6.857	6.428	6.	5.571	5.142	4.714	4.285	3.857	3.427
40	6.375	6.	5.625	5.25	4.875	4.5	4.125	3.75	3.375	3.
45	5.666	5.333	5.	4.666	4.333	4.	3.666	3.333	3.	2.666
50	5.1	4.8	4.5	4.2	3.9	3.6	3.3	3.	2.7	2.4
55	4.636	4.363	4.091	3.818	3.545	3.272	3.	2.727	2.454	2.181
60	4.25	4.	3.75	3.5	3.25	3.	2.75	2.5	2.25	2
65	3.923	3.692	3.461	3.23	3.	2.769	2.538	2.307	2.077	1.846
70	3.642	3.428	3.214	3.	2.785	2.571	2.357	2.142	1.928	1.714
75	3.4	3.2	3.	2.8	2.6	2.4	2.2	2.	1.8	1.6
80	3.187	3.	2.812	2.625	2.437	2.25	2.062	1.875	1.687	1 5
85	3.	2.823	2.647	2.47	2.294	2.117	1.941	1.764	1.588	1.411
90	2.833	2.666	2.5	2.333	2.166	2.	1.833	1.666	1.5	1.333
95	2.684	2.526	2.368	2.210	2.052	1.894	1.736	1.578	1.421	1.263
100	2.55	2.4	2.25	2.1	1.95	1.8	1.65	1.5	1.35	1.2
110	2.318	2.181	2.045	1.909	1.772	1.636	1.5	1.363	1.227	1.091
120	2.125	2.	1.875	1.75	1.625	1.5	1.375	1.25	1.125	1.
130	1.961	1.846	1.730	1.615	1.5	1.384	1.269	1.153	1 038	.923
SCREW WHEELS.	85	80	75	70	65	60	55	50	45	40

TABLE FOR MAKING THE UNIVERSAL TAPS, WITH THE MOST SUITABLE PROPORTIONS REQUISITE FOR GOOD WORKING TAPS USED BY HAND.

From $\frac{1}{4}$ to $\frac{9}{16}$ the head is turned the same size as the screw; the $\frac{5}{8}$, and all above, to pass through the holes screwed. As the same table shows the size of tap and bottom of screw, the workman will be enabled to make the tapping holes a size that will insure a full thread. The bottom of screw will give the size for drills, bits, etc.

Diameter of tap.	Bottom of thread, or tapping-hole.	Full length of tap.	Length of screw part.	Head length of square.	Number of threads per inch.	Wheels for cutting the screws.			
						Mandrel.	Interme-diate.	Pinion.	Screw.
$\frac{1}{4}$	$\frac{3}{16}$	$2\frac{1}{4}$	$1\frac{1}{8}$	$\frac{7}{16}$	20	40	80	20	100
$\frac{5}{16}$	$\frac{1}{4}$	$2\frac{1}{2}$	$1\frac{5}{16}$	$\frac{7}{16}$	18	40	80	20	90
$\frac{3}{8}$	$\frac{1}{4}$ and $\frac{3}{64}$	$2\frac{3}{4}$	$1\frac{1}{2}$	$\frac{9}{16}$	16	45	80	20	90
						Simple wheels.			
$\frac{7}{16}$	$\frac{11}{32}$	$3\frac{1}{8}$	$1\frac{3}{4}$	$\frac{5}{8}$	14	20	....	....	140
$\frac{1}{2}$	$\frac{13}{32}$	$3\frac{1}{2}$	2	$\frac{11}{16}$	12	20	....	....	120
$\frac{9}{16}$	$\frac{15}{32}$	$3\frac{3}{4}$	$2\frac{1}{8}$	$\frac{11}{16}$	12	20	....	....	120
$\frac{5}{8}$	$\frac{1}{2}$ and $\frac{1}{64}$	4	$2\frac{1}{4}$	$\frac{3}{4}$	11	20	....	....	110
$\frac{11}{16}$	$\frac{9}{16}$ and $\frac{1}{64}$	$4\frac{1}{4}$	$2\frac{3}{8}$	$\frac{3}{4}$	11	20	....	....	110
$\frac{3}{4}$	$\frac{5}{8}$	$4\frac{1}{2}$	$2\frac{5}{8}$	$\frac{3}{4}$ and $\frac{1}{16}$	10	20	....	....	100
$\frac{7}{8}$	$\frac{11}{16}$ and $\frac{3}{64}$	5	$2\frac{7}{8}$	$\frac{7}{8}$	9	20	....	....	90
1	$\frac{3}{4}$ and $\frac{3}{32}$	$5\frac{1}{2}$	$3\frac{1}{4}$	$\frac{7}{8}$	8	20	....	....	80
$1\frac{1}{8}$	$\frac{15}{16}$	6	$3\frac{1}{2}$	1	7	20	....	....	70
$1\frac{1}{4}$	1 and $\frac{3}{64}$	$6\frac{1}{2}$	$3\frac{3}{4}$	$1\frac{1}{8}$	7	20	....	....	70
$1\frac{3}{8}$	$1\frac{5}{32}$	7	$4\frac{1}{4}$	$1\frac{1}{4}$	6	20	....	....	60

TABLE FOR MAKING THE UNIVERSAL TAPS — (Continued.)

Diameter of tap.	Bottom of thread, or tapping-hole.	Full length of tap.	Length of screw part.	Head length of square.	Number of threads per inch.	Wheels for cutting the screws.	
						Mandrel.	Screw.
1 1/2	1 9/32	7 3/4	4 3/4	1 3/8	6	20	60
1 5/8	1 11/32	9	5 1/4	1 3/8	5	20	50
1 3/4	1 7/16 and 3/64	9 1/2	5 3/4	1 3/8	5	20	50
1 7/8	1 19/32	10	6 1/4	1 1/2	4 1/2	40	90
2	1 5/8 and 3/32	11	6 3/4	1 1/2	4 1/2	40	90
2 1/8	1 3/4 and 3/32	11 1/2	7 1/4	1 1/2	4 1/2	40	90
2 1/4	1 7/8 and 1/16	12	7 3/4	1 5/8	4	40	80
2 3/8	2 3/64	12 1/2	8 1/4	1 5/8	4	40	80
2 1/2	2 3/16	13	10 3/4	1 5/8	4	40	80
2 5/8	2 5/16	13	9 1/4	1 3/4	4	40	80
2 3/4	2 3/8	13 1/2	9 3/4	1 3/4	3 1/2	40	70
2 7/8	2 1/2	13 1/2	10	1 3/4	3 1/2	40	70
3	2 5/8	14	10	2	3 1/2	40	70

UNIVERSAL GAS-PIPE THREADS.

DIAMETER.	WHEELS FOR CUTTING, ETC.				Pitch.
	Mandrel.	Intermediate.	Pinion.	Screw.	
1 1/4, and all above	85	80	20	120	11.294
1	20	....	....	140	14.
3/4	20	....	......	140	14.
5/8	30	65	20	85	18.412
Small brass tube..	30	60	20	120	24.

HOW PUMICE STONE IS MADE.

Pumice stone is now prepared by molding and baking a mixture of white feldspar and fire-clay. This product is said to have superseded the natural stone in Germany and Austria.

NOTES ON THE WORKING OF STEEL.

1. Good soft heat is safe to use if steel be immediately and thoroughly worked.

It is a fact that good steel will endure more pounding than any iron.

2. If steel be left long in the fire it will lose its steely nature and grain, and partake of the nature of cast iron.

Steel should never be kept hot any longer than is necessary to the work to be done.

3. Steel is entirely mercurial under the action of heat, and a careful study of the tables will show that there must of necessity be an injurious internal strain created, whenever two or more parts of the same piece are subjected to different temperatures.

4. It follows that when steel has been subjected to heat not absolutely uniform over the whole mass, careful annealing should be resorted to.

5. As the change of volume due to a degree of heat increases directly and rapidly with the quantity of carbon present, therefore high steel is more liable to dangerous internal strain than low steel, and great care should be exercised in the use of high steel.

6. Hot steel should always be put in a perfectly dry place of even temperature while cooling. A wet place in the floor might be sufficient to cause serious injury.

7. Never let any one fool you with the statement that his steel possesses a peculiar property which enables it to be "restored" after being "burned;" no more should you waste any money on nostrums for restoring burned steel.

We have shown how to restore "overheated" steel.

For "burned" steel, which is oxidized steel, there is only one way of restoration, and that is through the knobbling fire or the blast furnace.

"Overheating" and "restoring" should only be allowable for purposes of experiment. The process is one of disintegration, and is always injurious.

8. Be careful not to overdo the annealing process; if carried too far it does great harm, and it is one of the commonest modes of destruction which the steelmaker meets in his daily troubles.

It is hard to induce the average worker in steel to believe that very little annealing is necessary, and that a very little is really more efficacious than a great deal.

WEIGHT AND NUMBER OF SQUARE NUTS IN A BOX OR KEG OF 200 POUNDS.

Width.	Thickness.	Hole.	Size of Bolt.	No. in 200 lbs.	Weight of Nut.
½	¼	7-32	¼	14,844	lbs.
⅝	5-16	9-32	5-16	7,880	....
¾	⅜	11-32	⅜	4,440	....
⅞	7-16	13-32	7-16	2,732	....
⅞	½	7-16	½	2,450	....
1	½	7-16		1,816	....
1⅛	½	½	9-16	1,390	....
1⅛	⅝	9-16	⅝	1,174	.17
1¼	⅝	9-16		898	.23
1⅜	¾	21-32	¾	662	.3
1½	¾	21-32		538	.37
1⅝	⅞	25-32	⅞	392	.51
1¾	⅞	25-32		326	.61
1¾	1	⅞	1	304	.66
2	1	⅞		224	.89
2	1⅛	15-16	1⅛	214	.93
2¼	1⅛	15-16		152	1.32
2¼	1¼	1 1-16	1¼	143	1.4
2½	1¼	1 1-16		108	1.85
2¾	1⅜	1 3-16	1⅜	83	2.41
3	1½	1 5-16	1½	65	3.1
3¼	1⅝	1 7-16	1⅝	51	4.
3½	1¾	1 9-16	1¾	42	4.8
3¾	1⅞	1 11-16	1⅞	32	6.3
4	2	1 13-16	2	27	7.4
4	2⅛	1⅞	2⅛	....	7¾
4¼	2¼	2	2¼	....	8¼
4¼	2⅜	2⅛	2⅜	....	8¼
4½	2½	2¼	2½	....	10¾
4¾	2¾	2 7-16	2¾	....	13¼
5	3	2 11-16	3	....	14

AMOUNT OF HEAT REQUIRED TO MELT WROUGHT IRON.

The temperature necessary to melt wrought iron lies between 4,000° and 5,000° F., and even at that tremendous heat, wrought iron is only rendered fluid by the addition of a small amount of aluminum.

WEIGHT AND NUMBER OF HEXAGON NUTS IN A KEG OR BOX OF 200 POUNDS.

Width.	Thick-ness.	Hole.	Size of Bolt.	No. in 200 lbs.	Weight of Nut.
½	¼	7-32	¼	17,332	lbs.
⅝	5-16	9-32	5-16	8,964	....
¾	⅜	11-32	⅜	5,016	....
⅞	7-16	13-32	7-16	2,988	....
⅞	½	7-16	½	2,674	......
1	½	7-16		2,160	......
1⅛	9-16	½	9-16	1,445	......
1⅛	⅝	9-16		1,310	.15
1¼	⅝	9-16	⅝	1,028	.2
1¼	¾	9-16		920	.22
1⅜	¾	21-32	¾	752	.27
1½	⅞	21-32		510	.38
1⅝	⅞	25-32	⅞	450	.44
1⅝	1	25-32		428	.47
1¾	1	⅞	1	372	.54
1¾	1⅛	⅞		336	.6
2	1¼	15-16	1⅛	211	.95
2¼	1⅜	1 1-16	1¼	159	1.26
2½	1½	1 3-16	1⅜	119	1.68
2¾	1⅝	1 5-16	1½	88	2.27
3	1¾	1 7-16	1⅝	69	2.9
3¼	1⅞	1 9-16	1¾	56	3.6
3½	2	1 11-16	1⅞	44	4.6
3½	2	1 13-16	2	43	4.7
4	2	1 13-16		29	6.9
3¾	2⅛	1⅞	2⅛	....	5½
3¾	2¼	2	2¼	....	5½
4	2⅜	2⅛	2⅜	....	6¼
4¼	2½	2¼	2½	....	7¼
4½	2¾	2 7-16	2¾	....	9¼
4¾	3	2 11-16	3	....	11½

HOW TO PREVENT GEAR TEETH FROM BREAKING.

Gear teeth generally have one corner broken off first, after which they rapidly go to pieces. This may be avoided and the teeth made much stronger by thinning down the edges with a file, thereby bringing the whole strain along the centre of the tooth. Gear teeth fixed this way will not break unless the strain be sufficient to break off the whole tooth.

NUMBER OF LIGHTS OF WINDOW GLASS IN A BOX OF 50 FEET.

Size.	No. Lights.	Size.	No. Lights.	Size.	No. Lights.
6x 8	150	28	16	50	5
7x 9	115	30	15	30x38	7
8x10	90	18x22	18	40	6
11	82	24	17	42	6
12	75	26	16	44	6
13	69	28	14	46	5
14	64	30	14	48	5
9x12	67	32	13	50	5
13	62	20x26	14	52	5
14	57	28	13	54	4
15	53	30	12	32x40	6
10x13	56	32	11	42	6
14	52	34	11	32x44	5
15	48	36	10	46	5
16	45	22x28	12	48	5
11x14	47	30	11	50	5
15	44	32	10	52	4
16	41	34	10	54	4
18	39	36	9	56	4
12x15	40	38	9	34x44	5
16	38	24x30	10	46	5
18	34	32	10	48	5
20	30	24x34	9	50	4
13x16	35	36	9	52	4
18	31	38	8	54	4
20	28	40	8	56	4
22	25	26x32	9	58	4
14x18	29	34	8	60	4
20	26	36	8	36x46	4
22	24	38	7	48	4
24	22	40	7	50	4
15x18	27	42	7	52	4
20	24	44	6	54	4
22	22	28x36	7	56	4
24	20	38	7	58	3
26	19	40	7	36x60	3
16x20	23	42	6	62	3
22	21	44	6	64	3
24	19	46	6	38x46	4
26	17	48	5	48	4

NUMBER OF LIGHTS OF WINDOW GLASS IN A BOX OF 50 FEET.—Continued.

Size.	No. Lights.	Size.	No. Lights.	Size.	No. Lights
50	4	60	3	66	3
52	4	40x62	3	68	3
54	4	64	3	70	2
56	3	66	3	44x54	3
58	3	40x68	3	56	3
60	3	70	3	58	3
62	3	42x50	3	60	3
64	3	52	3	62	3
66	3	54	3	64	3
40x48	4	56	3	66	2
50	4	58	3	68	2
52	3	60	3	70	2
54	3	62	3	72	2
56	3	64	3		

COMBUSTIBILITY OF IRON PROVED.

Combustion is not generally considered one of the properties of iron, yet that metal will, under proper conditions, burn readily. The late Professor Magnus, of Berlin, Germany, devised the following method of showing the combustibility of iron: A mass of iron filings is approached by a magnet of considerable power, and a quantity thereof is permitted to adhere to it. This loose, spongy tuft of iron powder contains a large quantity of air imprisoned between its particles, and is, therefore, and because of its extremely comminuted condition, well adapted to manifest its combustibility. The flame of an ordinary spirit lamp or Bunsen burner readily sets fire to the finely divided iron, which continues to burn brilliantly and freely. By waving the magnet to and fro, the showers of sparks sent off produce a striking and brilliant effect.

The assertion that iron is more combustible than gunpowder, has its origin in the following experiment, which is also a very striking one: A little alcohol is poured into a saucer and ignited. A mixture of gunpowder and iron filings is allowed to fall in small quantities at a time into the flame of the burning alcohol, when it will be observed that the iron will take fire in its passage through the flame, while the gun-

powder will fall through it and collect beneath the liquid alcohol below unconsumed. This, however, is a scientific trick, and the experiment hardly justifies the sweeping assertion that iron is more combustible than gunpowder. The ignition of the iron under the foregoing circumstances is due to the fact that the metal particles being admirable conductors of heat, are able to absorb sufficient heat in their passage through the flame—brief as this is—and they are consequently raised to the ignition point. The particles of the gunpowder, however, are very poor conductors of heat, comparatively speaking, and, during the exceedingly brief time consumed in their passage through the flame, they do not become heated appreciably, or certainly not to their point of ignition. Under ordinary circumstances, gunpowder is vastly more inflammable than iron.

Another method of exhibiting the combustibility of iron, which would appear to justify the assertion that it is really more combustible than gunpowder, is the following: Place in a refractory tube of Bohemian glass a quantity of dry, freshly-precipitated ferric exide. Heat this oxide to bright redness, and pass a current of hydrogen through the tube. The hydrogen will deprive the oxide of its oxygen, and reduce the mass to the metallic state. If, when the reduction appears to be finished, the tube is removed from the flame, and its contents permitted to fall out into the air it will take fire spontaneously and burn to oxide again. This experiment indicates that pure iron, in a state of the extremest subdivision, is one of the most combustible substances known — more so, even, than gunpowder and other explosive substances which require the application of considerable heat, or a spark, to ignite them.

HOW IRON BREAKS.

Hundreds of existing railway bridges which carry twenty trains a day with perfect safety would break down quickly with under twenty trains an hour, writes a British civil engineer. This fact was forced on my attention nearly twenty years ago, by the fracture of a number of iron girders of ordinary strength under a five-minute train service. Similarly, when in New York last year, I noticed, in the case of some hundreds of girders on the elevated railway, that the alternate thrust and pull on the central diagonals from trains passing every two or three minutes had developed a weakness which necessitated the bars being replaced by stronger ones, after a very short service. Somewhat the same thing

had to be done recently with a bridge over the river Trent, but, the train service being small, the life of the bars was measured by years instead of months. If ships were always among great waves the number going to the bottom would be largely increased. It appears natural enough to every one that a piece, even of the toughest wire, should be quickly broken if bent back and forward to a sharp angle; but, perhaps, only to locomotive and marine engineers does this appear equally natural that the same results would follow in time if the bending were so small as to be quite imperceptible to the eye. A locomotive crank axle bends but one eighty-fourth of an inch, a straight driving-axle a still smaller amount, under the heaviest bending stresses to which they are subject, and yet their life is limited. During the year 1883 one iron axle broke in running, and one in fifteen was renewed in consequence of defects. Taking iron and steel axles together, the number then in use on the railways of the United Kingdom was 14,847, and of these 911 required renewal during the year. Similarly, during the past three years, no less than 228 ocean steamers were disabled by broken shafts, the average safe life of which is said to be about three or four years. Experience has proved that a very moderate stress, alternating from tension to compression, if repeated about 100,000,000 times. will cause a fracture as surely as bending to an angle only ten times.

VALUE OF EMERY WHEELS.

The increased quantity and quality of work that goes out of the modern machine shop is due to the skillful use of solid emery wheels. A grain of sand from the common grindstone, magnified, would look like a cobble stone, a fracture of which shows an obtuse angle, whereas a grain of corundum or emery would look like a rhomboid, always breaking with a square or concave fracture. No matter how much it is worn down in use, it does not lose its sharpness; hence it is evident that the grindstone rubs or grinds and heats the work brought in contact with it, while the corundum, or emery wheel, with its sharp, angular grit, cuts like a file or angular saw.

There are two general classes of emery wheels in the market—one class of wheels has the grains of emery joined and consolidated by a pitchy material, as rubber, linseed oil, shellac, etc. These must run at a high speed to burn out the cementing material by friction, loosening the worn-out grains, and thus revealing new cutting angles. These are non-porous

wheels. Truing up this class of wheels is done with a diamond tool.

The other class consists of two kinds, one made by mixing the emery with a mineral cement and water into a paste, which will harden and bind the grains together; the other kind, by mixing the emery with a mineral flux or clay, molding into shape, and burning in a muffle at a high temperature. These are porous wheels, in which the grains of emery are held together by matter having affinity therefor. This class of wheels, unlike the grindstone, has sharp grains of emery bedded together among matter which, in some cases, is as hard and sharp as the emery itself. Such wheels cut very greedily, and do not need to be run at any particular speed.

The dresser, made of hardened steel picks, is the proper tool for truing up this class of wheels.

Manufacturers in metal goods aiming at reducing the cost of production, would do well to look into the adaptability of the solid emery wheels or rotary file, and other labor-saving machinery, before deciding on reducing labor wages.

THE SECRET OF CAST STEEL.

The history of cast steel, remarks a contemporary, presents a curious instance of a manufacturing secret stealthily obtained under the cloak of an appeal to philanthropy. The main distinction between iron and steel, as most people know, is that the latter contains carbon. The one is converted into the other by being heated for a considerable time in contact with powdered charcoal in an iron box. Now, steel thus made is unequal. The middle of a bar is more carbonized than the ends, and the surface more than the center. It is, therefore, unreliable. Nevertheless, before the invention of cast steel, there was nothing better. In 1760 there lived at Attercliffe, near Sheffield, a watchmaker named Huntsman. He became dissatisfied with the watch-spring in use, and set himself to the task of making them homogeneous. "If," thought he, "I can melt a piece of steel and cast it into an ingot, its composition should be the same throughout." He succeeded. His steel soon became famous. Huntsman's ingots for fine work were in universal demand. He did not call them cast steel. That was his secret. About 1780 a large manufactory of this peculiar steel was established at Attercliffe. The process was wrapped in secrecy by every means within reach. One midwinter night, as the tall chimneys of the Attercliffe steel works belched forth their smoke

a traveler knocked at the gate. It was bitterly cold, and the snow fell fast, and the wind howled across the moat. The stranger, apparently a plowman or agricultural laborer seeking shelter from the storm, awakened no suspicion. Scanning the wayfarer closely, and moved by motives of humanity, the foreman granted his request, and let him in. Feigning to be worn out with cold and fatigue, the old fellow sank upon the floor, and soon appeared to sleep. That, however, was far from his intention. He closed his eyes apparently only. He saw workmen cut bars of steel into bits, place them in crucibles, and thrust the crucibles into a furnace. The fire was urged to its extreme power until the steel was melted. Clothed in wet rags to protect themselves from the heat, the workmen drew out the glowing crucibles and poured their contents into a mold. Mr. Huntsman's factory had nothing more to disclose. The secret of making cast steel had been discovered.

IRON AND STEEL MAKING IN INDIA.

Indian Engineering, in a recent issue, gives a most interesting account of the manufacture of iron and steel in India, which we reproduce below:

Notwithstanding the simplicity of their processes, the iron turned out by the natives is of superior quality, and is selling very cheaply; so, for instance, a mound of horseshoes sells at Rs. seven, and of clamp iron Rs. six-eighths. These low prices are accounted for by cheap fuel, the rich ores, the miserably cheap labor, and the absence of managing expenses.

There are reasons to believe that "Wootz" (Indian cast steel) has been exported to Asia Minor more than 2,000 years ago; how long, however, its manufacture has been commenced, cannot be traced.

The following is a description of the method for making "Wootz" employed by the natives at Hyderabad.

The minute grains or scales of iron are diffused in a sandstone-like gneiss or mica schist, passing into a hornblende slate. These rocks are excavated with crowbars, and then crushed between stones; if hard, this is done after preliminary roasting.

The ore is then separated from the powdered rock by washing. This was at a village called Dundurti, but the process of manufacture was the same as that at Kona Samundrum, twelve miles south of the Godavari, and twenty-five from Nirmal, which has been described by Dr. Voysey. The furnace was made of a refractory clay, derived from decom-

posed granite, and the crucibles are made of the same, ground to a powder together with fragments of old furnace and broken crucibles kneaded up with rice, chaff and oil. He states that no charcoal was put into the crucible, but some fragments of old glass slag were. A perforation was made in the luted cover. Two kinds of iron, one from Mirtapalli and the other from Kondapore, were used in the manufacture of the steel. The former was made from magnetic sand, and the latter from an ore found in the iron clay (? laterite) twenty miles distant; the proportions used of each were 3 to 2.

This mixture being put into the crucible in small pieces, the fire was kept up at a very high heat for twenty-four hours by means of four bellows, and was then allowed to cool down. Cakes of steel of great hardness, and weighing on the average 1½ lbs., were taken from each crucible. They were then covered with clay and annealed in the furnace for twelve to sixteen hours; then cooled, and, if necessary, the annealing was repeated till the requisite degree of malleability had been obtained. The Telinga name for this steel was "Wootz," and "Kurs" or cake of it, weighing 110 rupees, was sold on the spot for eight annas. The daily produce of a furnace was 50 seers, or in value Rs. 37.

Also Mysore is a country where the manufacture of iron and steel by the natives was of great importance owing to the excellent quality of its produce.

The iron was made from black sand, which the torrents, formed in the rainy season, brought down from the rocks. The furnaces in the Chin-Narayan Durga taluk were on a small scale, the charge of ore being 42½ pounds, from which about 47 per cent. of the metal was obtained. Work was carried on for only four months, the smelters taking to cultivation during the remainder of the year. The stone ore was smelted in the same way as the iron sand, but the latter, it is said, was alone fit for manufacturing into steel. There were in this vicinity five steel forges, four in the above taluk, and one at Devaraya, Durga.

The furnace, of which a figure is given by Buchanan, consisted of a horizontal ash-pit and a vertical fire-place, both sunk below the level of the ground. The ash-pit was about three-fourths of a cubit in width and height, and was connected with a refuse pit into which the ashes could be drawn. The fire-place was a circular pit, a cubit in width, which was connected with the ash-pit, being from the surface of the ground to the bottom two cubits in depth. A screen or mud-wall five feet high, protected the bellows-man from heat and

sparks. The bellows were of the ordinary form, a conical leather sack with a ring at the top, through which the operator passed his arm.

The crucibles, made of unbaked clay, were conical in form, and of about one pint capacity. Into each a wedge of iron and three rupees' weight of the stem of the *Cassia Auriculata* and two green leaves of a species of convolvulus or *Ipomaia* were put. The mouths of the crucibles were then covered with round caps of unbaked clay, and the junctures well luted.

They were then dried near the fire, and were ready for the furnace. A row of them was first laid round the sloping mouth of the furnace; within these another row was placed and the center of the dome, so formed, was occupied by a single crucible, making fifteen in all.

The crucible opposite the bellows was then withdrawn, and its place occupied by an empty one, which could be withdrawn in order to supply fuel below. The furnace, being filled with charcoal, and the crucibles covered with the same, the bellows were plied for four hours, after which the operation was completed. When the crucibles were opened, the steel was found melted into a button with a sort of crystalline structure on its surface, which showed that complete fusion had taken place. These buttons weighed about twenty-four rupees. There were thirteen men to each furnace, a head man to make and fill the crucibles, and four relays of three men each, one to attend the furnace, and two for the bellows.

Each furnace manufactured forty-five pagodas' worth of 1,800 wedges of iron into steel. The net profit was stated to be 1,253 fanams, but into the further details as to cost it is not, perhaps, necessary to enter. The total production of steel in this vicinity was estimated to be 152 cwt., or about £300 per annum.

The principal sources of the ores were the magnetic sand found in rivers, and the richer portion of the laterite

THE FLASH-POINT OF VARIOUS HYDROCARBONS.

The following table gives the temperature at which various hydrocarbons give off inflammable vapors:

Open Test.	Flash Point.	Fire Point.
Brandy, as usually sold retail......	69 F.	92 F.
Whisky, " "	72	96
Gin, " "	72	101

Fire Test.	Flash Point.	Fire Point.
Petroleum (ordinary American lamp oil)	73	104
Saxoline	110	150
Ordinary high-test Petroleum	110–120	140–160
Crystal Oil	150	180
Downer's Oil	270	310
Mineral Sperm	310	330

HOW BREAKS IN SUBMARINE CABLES ARE DETECTED AND REPAIRED.

The following is an account of how submarine cables are found and repaired at an immense depth:

The break, which the "Minia" was sent to repair, occurred early last summer. The officers of the company first located the distance of the break from the stations on shore, on each side of the ocean. The details of the instrument by which this is done are not easily described, though easily understood in principle. The machine consists of a series of coils of wire, which offer a known resistance to the electric current. Enough of the coils are connected to make a resistance equal to the resistance offered by the entire cable when it is in working order, and thus, when the machine and the cable are connected, a balance is effected. But, if the cable should break, the balance is destroyed, because that portion of the cable between the shore station and the break, wherever it may be, will offer less resistance to the electric current than the entire cable would do. Enough coils of wire are therefore disconnected from the machine to restore the balance. The resistance of the part of the cable that remains intact is thus accurately determined by the number of coils remaining connected with the machine. Having, when the cable was intact, learned the resistance which a mile of the cable offers, by dividing the entire resistance by the number of miles of cable, it is easy to find how many miles of cable are still in good order, by dividing the entire resistance of the piece by the known resistance of one mile

Having determined how many miles from the shore station the break is, orders are sent to go to the place, pick up the ends, and splice them to new piece. Having received such an order and acted on it, Captain Trott found himself and his ship, on July 25th last, in latitude 42° 30′ north, and longitude 46° 30′ west, or just to the eastward of the Grand Banks of Newfoundland, with one of the hardest jobs before him that he had had in some time, for sounding

showed that the water was about 13,000 feet, or a good deal more than two miles deep. He knew he was somewhere near the break in the cable, but he did not know absolutely within about three or four miles, because, while he had been able to determine his own position by repeated observations of the sun and stars, he could not tell how accurate the observations of the officers of the ship laying the cable had been.

The first work done was to get a series of soundings over a patch of the sea aggregating twenty-five or thirty square miles. The sounding apparatus consisted of an oblong shot of iron, weighing about thirty-two pounds, attached to a pianoforte wire in such a way that, when lowered to the bottom, the shot would jab a small steel tube into the mud down there, and would then release itself from the wire, and allow the sailors to draw up the tube with the mud in it. The moment the weight was released, the men on deck stopped paying out the wire, and thus, knowing how much wire had been run out, they were able to tell the depth. It is a fact that it took twenty-four minutes and ten seconds for the weight of the sounding apparatus to reach bottom in 2,097 fathoms of water.

The ship was now ready to begin the search proper for the cable. She was run off at right angles to the line of the cable for a distance of five miles, and a buoy got down to mark the limits of the territory to be grappled over in that direction. Buoys were afterward set elsewhere to mark the other limits of the territory. The grappling iron was lowered over the bows, the rope attached to it passing over one of the three big grooved wheels that revolve where the bowsprit of an ordinary vessel stands.

The grappling iron used is the invention of Captain Trott. It looks something like a four-pronged anchor. It has a shaft four feet long, and four arms about a foot long, that are set at right angles to each other at the bottom of the shaft. Right in each crotch formed by the arms is a little button that has a spring behind it that may be regulated in strength. The button projects a third of an inch into the crotch. The angle of the arms with the shaft is so small that a rock could not get down in so far as to reach the button; but, when the cable is caught by the hooks, it presses down against the button, and thus closes an electrical circuit through a copper wire running through the grapnel's rope and the grapnel itself, and a bell is set ringing upon deck. But the experienced man in charge of the grappling are generally able to tell what the hook has hold of without the aid of the bell.

They judge by the strain on the rope, which is indicated by a dynamometer on deck. The ordinary strain on the dynamometer is from 3 to 3¼ tons when the grapnel is dragging freely over a smooth bottom as the vessel forges slowly ahead. Sometimes a rock catches on the hooks. This frequently breaks off an arm, but sometimes it fetches clear, the strain indicated by the dynamometer informing the old sailor man in charge whether an accident has happened or not.

It took two hours and twenty minutes to get the grappling iron from the bow of the ship down to the bottom of the sea, 13,000 feet below. The cable used to drag it with is the patent wire and hemp invention of the captain. The dragging began on July 25th, the day of arrival, but they swept backward and forward over the territory for ten days without finding the broken telegraph cable. A good part of the time they were steaming back and forth day and night, and the only time when they were not doing so was when the weather was too bad. On such occasions they went to the buoy at the supposed end of the broken cable, and hove to till the gale was ended.

Finally, on August 5th, the bell rang, indicating that the grapnel had caught the cable. The grapnel drag rope was thereupon fastened to a buoy and thrown overboard. Then the steamer went off two miles toward the end of the broken cable and got out a cutting grapnel. This is like the other one, except that there are knives in the crotches. When these crotches catch the cable and strain comes on them, they cut the cable off clean.

"Why did you cut off the cable there?" was asked.

"Because, if we had tried to get up the bight of the cable where we first found it, the cable might have broken under the strain. That cable was laid in 1869, and is getting pretty well along in years. It would have been as apt to break on the shore side as the other, but, when we had only an end of two miles to deal with, we were sure of being able to get up without damage. We grappled European end first."

Having cut off the cable, the vessel returned to the buoy on the grappling rope, and, getting the rope inboard again, led it to a drum six feet in diameter located on the upper deck and operated by a steam engine. Then they began to wind in the grapnel rope and hoist the old cable to the bows. They started the drum at 1:20 in the afternoon of August 5, and at 7:51 had the bight of it at the bow of the ship. Then the two miles and odd of end that was hanging down from the bow was fished up and stretched in lengths along the deck until the end was reached This was connected with a

very complete cable telegraph office located amidships, and a second later the operators who had been on watch for days in the British station awaiting this event saw the flashes on a mirror in their office that told them all about it.

Sometimes it happens that, when an end of the cable is picked up in this way, and an attempt is made to communicate with the shore, it is found that there is another break, and that they have only the end of an odd section lying loose. Then they have to drop that over, after testing it to see how long it is, and go on toward the shore and begin over again. In this case, however, they found that they had hold of a sound wire to Great Britain. Without any delay, the end of a new cable was spliced to the old end brought from the bottom. Two experts, one who is trained in splicing cores, and one who is trained in splicing the outside or sheathing, are employed in this work.

When the splice was completed and tested, and found perfect, the cable was started, running out around drums and grooved wheels controlled by brakes, and over the stern, the old end having been led fair through these sheaves before the splicing was done. Then the ship headed for shoal water, and ran away at from three to four knots an hour until over a part of the banks where work could be done more easily than where the water was more than two miles deep. Of course this involved the abandonment of a good many miles of old cable, but the old cable wasn't of very much importance anyhow.

Arriving in shoal water, the end of the new piece was attached to a buoy and put overboard. Then the old cable was grappled and cut as before, and a new piece spliced to it. Then the ends of the two new pieces were spliced together and the job was complete. It had taken nearly two months to do it, although in the meantime two easier jobs were attended to, and a trip to Halifax for provisions was made, not to mention the encountering of the storm that damaged the rudder.

The "Minia" has a crew of ninety, all told, including the captain, three deck officers, a navigator, three expert electricians, four engineers, a purser and a surgeon. A blacksmith and a boiler maker, with their tools, are carried. There are three big, round tanks to hold the 600 miles of cable carried, which includes sizes to fit all the old cables under the charge of this ship. There is a cell-room where the electricity for telegraphing is generated, and two dynamos with their engines, one to furnish electricity for a system of arc lights used when at work at night, and the other for the incandes-

cent system that lights the ship below decks. The main saloon is large, and is comfortably and handsomely fitted. The captain has a cabin under the turtle-back aft, as fine as any captain could wish for, and the other officers have rooms below that are as well fitted as those usually occupied by naval officers. The crew are all expert men, and get pay that averages a good deal better than the pay in the packet service between New York and Liverpool. The entire crew is kept under pay the year round, the ship making her head-quarters at Halifax when not engaged in repairing cables. They are as comfortable a lot of sailor men as one could find anywhere.

THE USELESSNESS OF LIGHTNING RODS.

The uselessness of the lightning rod is becoming so generally understood that the agents find their vocation a a trying one. Fewer and fewer rods are manufactured each year, and the day will come when a lightning rod on a house will be regarded in the same light as a horseshoe over a man's door.

The breaking strain on various metals is shown in the following table, the size of the rod tested being in each case one inch square, and the number of pounds the actual breaking strain:

	Pounds.
Hard steel	150,000
Soft steel	120,000
Best Swedish iron	84,000
Ordinary bar iron	70,000
Silver	41,000
Copper	35,000
Gold	22,000
Tin	5,500
Zinc	2,600
Lead	860

To make varnish adhere to metal, add five-hundredths per cent. of boracic acid to the varnish.

Machinery will do almost anything, and what machinery can't do a woman can with a hairpin.

To find the weight of a cast-iron ball, Haswell says—Multiply the cube of the diameter in inches by 1365, and the product is the weight in pounds.

NUMBER OF REVOLUTIONS OF WATCH WHEELS.

Very few who carry a watch ever think of the unceasing labor it performs under what would be considered shabby treatment for any other machinery. There are many who think a watch ought to run for years without cleaning, or a drop of oil. Read this and judge for yourself: The main wheel in an ordinary American watch makes 4 revolutions a day of 24 hours, or 1,460 in a year. Next, the center wheel, 24 revolutions in a day, or 8,760 in a year. The third wheel 192 in a day, or 59,080 in a year. The fourth wheel, 2,440 in a day, or 545,600 in a year. The fifth, or 'scape wheel, 12,960 in a day, or 4, 728,200 in a year. The ticks or beats are 388,800 in a day, or 141,882,000 in a year.

A VALUABLE POINT FOR MOLDERS.

It is claimed that a saving, as well as a better job, can be effected by the substitution of the following for the coal dust and charcoal used with green sand: Take one part common tar, and mix with 20 parts of green sand; use the same as ordinary facing. The castings are smooth and bright, as tar prevents metal from adhering to the sand, prevents formation of blisters, and helps the production of large castings by absorbing the humidity of the sand.

METRICAL EQUIVALENTS.

As in much of the scientific literature of the steam engine the metrical system of weights and measures is used, we publish the following equivalents, which may be of use to our readers in readily reducing them to British units:

1 kilogrammetre	7,233 foot pounds.
1 foot pound	.188 kilogrammetre.
1 French horse power (chevelvapeur) 75 kilogrammetres per second	.9863 horse power.
1 British horse power	1.0139 chevaux.
1 kilogramme per cheval	2,239 pounds H. P.
1 pound per horse power	.447 kilo. per cheval.
1 caloric, or French heat unit	3.968 British units.
1 British thermal unit	.252 caloric.
French mechanical equivalent, 423.55 (usually called 424) kilogrammetres	3063. 5 ft. pounds.
English mechanical equivalent, 772 foot pounds	10.76 kilogrammetres.

A NEW ALLOY.

An alloy, the electrical resistance of which diminishes with increase of temperature, has recently been discovered. It is composed of copper, manganese and nickel. Another alloy, due to the same investigator, the resistance of which is practically independent of the temperature, consists of 70 parts of copper combined with 30 of ferro-manganese

USE OF NATURAL GAS IN CUPOLAS.

At Pittsburgh, Pa., natural gas has been utilized in cupolas for ordinary castings. The apparatus consists of a series of pipes, covered with fire-clay tiles, and, at the same time, ventilating the pipes with a current of air. A combustion chamber is necessarily connected with the furnace, to insure the required heat and prevent the chilling of the furnace.

A NEW CEMENT.

A cement called magnesium oxychloride, or white cement, has been discovered, and is now manufactured in California, as we learn from an exchange. It is composed of one-half (½) magnesium oxide, which is obtained from the magnesite deposits in the Coast Range, and one-half (½) magnesium chloride, obtained from various sea-salt manufactories throughout the State. It may be used for sidewalks, and for interior decorating, and in appearance resembles pure white marble. It has a natural polish, and, above all, is much cheaper than any of the other substances now in use.

HOW TO CAST A FACE.

The person whose face is to be "taken" is placed flat upon his back, his hair smoothed back by pomatum to prevent it covering any part of the face, and a conical piece of paper or a straw, or a quill put in each nostril to breathe through. The eyes and mouth are then closed and the entire face completely and carefully covered with salad oil. The plaster, mixed to the proper consistency, is then poured in large spoonfuls to the thickness of one-quarter or one-half inch. In a few minutes this can be taken off as if it were a film. When a cast of the entire head or of the whole human figure is required, either a cast of the face is added to a mass of clay, which is to be modeled to the required figure, or the whole figure is modeled from drawings prepared for that purpose This is the work of the sculptor,

When the clay model is finished, a mold is made from it as in the former cases. If the model be a bust, a thin ridge of clay is laid along the figure from the head to the base, and the front is first completed up to the ridge by filling up the depressions two or three inches deep. The ridge of clay is now removed, the edges of the plaster are oiled, and the other half is done in a similar way. The two halves are likewise tied together with cords, and the plaster is poured in. In complicated figures, say a "Laocoön," the statue is oiled and covered with gelatine, which is cut off in sections by means of a thin, sharp knife, each piece serving as a mold for its own part of the new statue.

MELTING POINTS OF METALS.

Metals.	Centigrade.		Fahrenheit.	
Aluminum.............	degrees	700	degrees	1,292
Antimony	"	425	"	797
Arsenic...............	"	185	"	365
Bismuth	"	264	"	507.2
Cadmium	"	320	"	608
Cobalt...............	"	1,200	"	2,192
Copper................	"	1,091	"	1,995.8
Gold	"	1,381	"	2,485.6
Indium	"	176	"	348.8
Iron, wrought.........	"	1,530	"	2,786
Iron, cast	"	1,200	"	2,192
Iron, steel	"	1,400	"	2,552
Lead	"	334	"	617
Magnesium............	"	235	"	455
Mercury	"	—40	"	—40
Nickel	"	1,600	"	2,912
Potassium.............	"	62	"	143.6
Platinum	"	2,600	"	4,712
Silver	"	1,040	"	1,904
Sodium	"	96	"	172.8
Tin	"	235	"	455
Zinc	"	412	"	773.6

THE HIGHEST RAILROAD IN THE UNITED STATES.

The highest railroad in the United States is the Denver & Rio Grande, Marshall Pass, 10,853 feet.

WEIGHT AND SPECIFIC GRAVITY OF METAL.

Metals.	Wt. pr cubic ft.	Wt. pr cubic ft.	Specifc grav.
	Lbs.	Lbs.	
Aluminum	166	.096	2.67
Antimony, cast	419	.242	6.72
Bismuth	613	.353	9.822
Brass, cast	524	.3	8.4
Bronze	534	.308	8.561
Copper, cast	537	.31	8.607
" wire	555	.32	8.9
Gold, 24 carat	1208	.697	19.361
" standard	1106	.638	17.724
Gun-metal	528	.304	8.459
Iron, cast	450	.26	7.21
" wrought	485	.28	7.78
Lead, cast	708	.408	11.36
" rolled	711	.41	11.41
Mercury	849	.489	13.596
Platinum	1344	.775	21.531
" sheet	1436	.828	23.
Silver, pure	654	.377	10.474
" standard	644	.371	10.312
Steel	490	.284	7.85
Tin, cast	455	.262	7.29
Zinc	437	.252	7.

HOW TO MEND PATTERNS.

For mending patterns needing temporary repairs, or for making additions where but one or two molds are to be made, the following material will be found very useful. Melt together 1 pound beeswax, 1 pound rosin and one pound paraffine wax. It is well to note here that the beeswax intended is the wax made by the bees, and not the wax made by the wholesale dealers. The cheap wax sold to the shipping houses contains but a small portion of the article made by the bees, and a large proportion of soft paraffine wax. The result of using this compound wax instead of the genuine article, in any mixture, is to introduce too much paraffine and only a little beeswax. When the genuine article is used, this mixture will be found very useful for making addition to patterns, temporary patterns, and for a variety of purposes in pattern shop.

VALUE OF METALS.

Gold by the pound avoirdupois.

Vanadium (cryst. fused)	$4,792.40
Rubidium (wire)	3,261.60
Calcium (electrolyctic)	2,446.20
Tantalum (pure)	2,446.20
Cerium (fused globules)	2,446.20
Eithium (globules)	2,228.79
Lithium (wire)	2,935.44
Lubium (fused)	1,671.57
Didymium (fused)	1,620.08
Strontium (electrolyctic)	1,576.44
Indium (pure)	1,522.08
Ruthenium	1,304.64
Columbium (fused)	1,250.28
Rhodium	1,032.84
Barium (electrolyctic)	924.12
Tallium	738.39
Osmium	652.32
Palladium	498.30
Iridium	466.59
Uranium	434.88
Gold	299.72
Titanium (fused)	239.80
Tellurium "	196.20
Chromium "	196.20
Platinum "	122.31
Manganese "	108.72
Molydenum	54.34
Magnesium (wire and tube)	45.30
Potassium (globules)	22.65
Silver	18.60
Aluminum (bar)	16.30
Cobalt (cubes)	12.68
Nickel	3.80
Cadmium	5.26
Sodium	3.26
Bismuth (crude)	1.95
Mercury	1.00
Antimony	.36
Tin	.25
Copper	.22
Arsenic	.15
Zinc	.10
Lead	.06
Iron	.1¾

LENGTH PER COIL AND WEIGHT OF ROPE PER HUNDRED FATHOMS.

Manila and Sisal Rope.				Tarred Cordage.	
Diameter in inches.	Cir. in inches	Le'gth in feet.	Lbs. per 100 Fa	Le'gth in feet.	Lbs. per 100 Fa
¼ or 6th.	¾	1,300	12	840	18
5-16 or 9th.	15-16	1,300	17	840	29
⅜ or 12th.	1⅛	1,200	23	840	40
15 thread.	15 thread.	1,200	31	840	47
18 thread.	18 thread.	1,100	45	840	58
21 thread.	21 thread.	1,100	50	840	68
½	1½	990	52	960	64
9-16	1¾	990	70	960	79
⅝	2	990	83	960	94
¾	2¼	990	105	960	130
⅞	2½	990	125	960	140
15-16	2¾	990	155	960	170
1	3	990	175	960	207
1 1-16	3¼	990	205	960	238
1 3-16	3½	990	255	960	272
1¼	3¾	990	280	960	300
1 5-16	4	960	310	960	332
1⅜	4¼	960	355	960	376
1½	4½	960	410	960	440
1⅝	4¾	960	450	960	505
1 11-16	5	960	500	960	573
1¾	5¼	960	550	960	610
1⅞	5½	960	610	960	654
1 15-16	5¾	960	690	960	797
2	6	960	750	960	900
2 3-16	6½	960	845	960	1,057
2⅛	7	960	1,000	960	1,163
2½	7½	960	1,100	960	1,356
2⅝	8	960	1,270	960	1,613
3	9	960	1,595	960	2,013

HOW TO MAKE BRONZE MALLEABLE.

Domier has discovered that bronze is rendered malleable by adding to it from one-half to two per cent. of mercury.

WHEN A DAY'S WORK BEGINS.

The decision of the Supreme Court that a workman who has agreed to do work at a specified sum per hour, is not entitled to charge for the time spent in going to or returning from work, is one that equitably applies to some kinds of business, but not to others. Where house-building mechanics have several days' work to do at a building, and their tools and materials are on the spot, they are expected to report at the building in time to do a full day's work. Where they are doing odd jobs and are obliged to start from the shop in the morning, they do so at the regular hour for beginning work, thus reducing the hours of actual labor But they must be paid for the whole day, and the person for whom the work is done must be charged for the time occupied in going to and from the job; otherwise, the "boss" would have to pay his journeymen, for say ten hours' work, though accounting for only six hours work' in his bill to customers. In some of the small trades a journeyman will go to half a dozen houses in a day, doing an hour's work in each, and spending the other four hours in passing from one job to another. In one way or another he is bound to be paid for the whole time. If he can charge only for the actual working time, then his rates will be increased so as to compensate him for the time spent in service that is not to be paid for. The decision shows the importance of making agreements of this kind specific, both as to the rate of wages and the hours and kind of service.

CAMEL'S-HAIR BELTING.

Camel's-hair belting has been recently the subject of experiments at the Polytechnic school, at Munich, from which it appears that the strength of camel's-hair belting reaches 6,315 pounds per square inch, whilst that of ordinary belting ranges between 2,230 pounds and 5,260 pounds per square inch. A contemporary says the camel's-hair belt is said to work smoothly and well, and it is unaffected by acids.

TO PERFORATE GLASS.

In drilling glass, stick a piece of stiff clay or putty on the part where you wish to make the hole. Make a hole in the putty the size you want the hole, reaching to the glass, of course. Into this hole pour a little molten lead, when, unless it is very thick glass, the piece will immediately drop out.

HIGH SPEED GEARING.

During the last few years, and particularly since the adoption of double-heliacal teeth, a great increase has been made in speed at which gearing is run, and, in many cases, there are now successfully adopted speeds which in former days would have been regarded as utterly impracticable. The most striking instances of this which we have come across, is in the case of a pair of double-heliacal wheels at the works of Messrs. R. Johnson & Nephew, the well-known wire-drawers of Manchester. These wheels, which were cast by Messrs. Sharples & Co., of Ramsbottom, Lancashire, are 12 in. wide on the face, by 6 ft. 3 in. diameter, and they have now been running for over a year at 220 revolutions per minute, the pitch-line speed being thus 4,319 ft. per minute. Notwithstanding this enormous speed, the wheels run with scarcely any noise, and their working has been most satisfactory. This is the highest speed we have heard of for geared wheels, running iron to iron, and the fact that it has been adopted with success, is a most interesting one.

The large gear on the Corliss engine at the Centennial Exhibition was 30 feet in diameter, outside, and ran at 36 revolutions per minute. It had a 24-in. face, and the speed of the pitch-line is about 3,360 ft. per minute. This speed is exceeded by a similar gear, also made by Mr. Corliss, which is now running in a mill in Massachusetts. It is 30 ft. in outside diameter, and has a 30-in. face. It makes 50 revolutions per minute, and the speed of the pitch-line is not far from 4,670 ft. per minute. This is probably the highest speed at which any gear has yet been run continuously.

The Corliss gears are all accurately shaped by a revolving cutter; but it is probable that Messrs. Sharples & Co.'s gears are not cut, but cast, and then finished up by hand. If that is the case, their performance is much more remarkable than that of the Corliss gears.

THE WATCH AS A COMPASS.

Due south can be readily ascertained if one possesses a fairly correct watch and the position of the sun is distinguishable. Point the hour hand to the sun, and the south is exactly half-way between the hour and the figure XII on the watch. For instance suppose that it is 4 o'clock. Point the hand indicating IV to the sun and II on the watch is exactly south. Suppose that it is 8 o'clock, point the hand indicating VIII to the sun, and the figure X on the watch is due south.

LIABLE TO SPONTANEOUS COMBUSTION.

Cotton-seed oil will take fire even when mixed with twenty-five per cent. of petroleum oil; but ten per cent. of mineral oil mixed with animal or vegetable oil, will go far to prevent combustion.

Olive oil is combustible, and, mixed with rags, hay or sawdust, will produce spontaneous combustion.

Coal dust, flour-dust, starch (especially rye flour), are all explosive when with certain proportions of air.

New starch is highly explosive in its comminuted state, also sawdust in a very fine state, when confined in a close shute, and water directed on it. Sawdust should never be used in oil shops or warehouses to collect drippings or leakages from casks.

Dry vegetable or animal oil inevitably takes fire, when saturating cotton waste, at 180° F. Spontaneous combustion occurs most quickly when the cotton is soaked with its own weight of oil. The addition of forty per cent. of mineral oil (density .890) of great viscosity, and emitting no inflammable vapors, even in contact with an ignited body at any point below 338° F., is sufficient to prevent spontaneous combustion, and the addition of twenty per cent. of the same mineral oil doubles time necessary to produce spontaneous combustion.

Greasy rags from butter, and greasy ham bags.

Bituminous coal in large heaps, refuse heaps of pit coal, hastened by wet, and especially when pyrites are present in the coal; the larger the heaps the more liable.

Timber dried by steam pipes or hot water, or hot air heating apparatus, owing to fine iron dust being thrown off, in close wood-casings, or boxings round the pipes, from the mere expansion and contraction of the pipes.

Patent dryers from leakages into sawdust, etc., oily waste of any kind, or waste cloths of silk or cotton, saturated with oil, varnish, turpentine.

HOW COMBUSTION IN COAL IS PRODUCED.

In a ton of anthracite coal, there is about 1,830 lbs. of carbon, 70 lbs. of hydrogen and 52 lbs. of oxygen; while a ton of good bituminous coal is composed of 1,600 lbs. of carbon, 108 lbs. of hydrogen and 32 lbs. of oxygen. The combustion of coal proceeds from its combination with oxygen gas, and, when fuel of any kind combines with oxygen, heat is produced. All bodies, substances, gases and liquids, are composed of separate particles, often of molecules of inconceivable smallness. These particles, it is scientifically conceded,

are in motion among themselves, and this motion constitutes heat, for heat is only a kind of motion. This internal vibration of infinitesimal particles may be transmuted into a perceptible mechanical movement, or the mechanical movement may be converted into the invisible motion called heat. The oxygen combined with coal has a very considerable range of internal motion, and the combining process produces carbonic acid gas; and, the particles of this gas having a much smaller range of motion than the particles of the oxygen have, the difference appears in the form of heat.

CAPACITY OF CYLINDRICAL CISTERNS.

The following table shows the capacity in gallons for each foot in depth of cylindrical cisterns of any diameter:

Diameter.	Gallons.	Diameter.	Gallons.
25 ft.	3,059	7 ft.	239
20 ft.	1,958	6½ ft.	206
15 ft.	1,101	6 ft.	176
14 ft.	959	5 ft.	122
13 ft.	827	4½ ft.	99
12 ft.	705	4 ft.	78
11 ft.	592	3 ft.	44
10 ft.	489	2½ ft.	30
9 ft.	396	2 ft.	19
8 ft.	313		

HOW TO SELECT A HAND SAW.

A saw-maker has this advice to give to carpenters in the selection of a saw:

"See that it 'hangs' right. Grasp it by the handle and hold it in position for working to see if the handle fits the hand properly. A handle should be symmetrical, and the lines perfect. Many handles are made of the green wood; they soon shrink and become loose, the screws standing above the wood. An unseasoned handle is liable to warp and throw the saw out of shape. Try the blade by springing it, seeing that it bends evenly from point to butt in proportion as the width and gauge of the saw vary. The blade should not be too heavy in comparison to the teeth, as it will require more labor to use it. The thinner you can get a stiff saw the better; it makes less 'kerf' and takes less muscle to drive it.

"See that the saw is well set and has a good crowning breast. Place it at a distance from you; get a proper light on it, and you can see if there has been any imperfections in grinding or hammering."

FROM ONE TON OF COAL.

From one ton of ordinary gas coal may be produced 1,500 pounds of coke, 20 gallons of ammonia water and 140 pounds of coal tar. By destructive distillation the coal tar will yield 69.5 pounds of pitch, 17 pounds of creosote, 14 pounds of heavy oils, 9.5 pounds of naphtha yellow, 6.3 pounds of naphthaline, 4.75 pounds of naphthol, 2.25 pounds of solvent naphtha, 1.5 pounds of phenol, 1.2 pounds of aurine, 1.1 pounds of benzine, 1.1 pounds of analine, 0.77 of a pound of toludine, 0.46 of a pound of anthracine and 0.9 of a pound of toulene. From the latter is obtained the new substance known as saccharine, which is 530 times as sweet as the best cane sugar, one part of it giving a very sweet taste to a thousand parts of water.

HOW TO SELECT ROPE.

A German paper, in an article on the present methods of rope manufacture from hemp, and the determination of the different qualities and the probable strength simply from the appearance, lays down the following rules: A good hemp rope is hard but pliant, yellowish and greenish gray in color, with a certain silvery or pearly luster. A dark or blackish color indicates that the hemp has suffered from fermentation in the process of curing, and brown spots show that the rope was spun while the fibers were damp, and is consequently weak and soft in those places. Again, sometimes a rope is made with inferior hemp on the inside, covered with yarns of good material—a fraud, however, which may be detected by dissecting a portion of the rope, or, in practical hands, by its behavior in use; other inferior ropes are made with short fibers, or with strands of unequal strength or unevenly spun—the rope in the first case appearing wooly, on account of the number of ends of fiber projecting, and, in the latter case, the irregularity of manufacture is evident on inspection by any good judge.

THINGS THAT WILL NEVER BE SETTLED.

Whether a long screw-driver is better than a short one of the same family.

Whether water-wheels run faster at night than they do in the day time.

The best way to harden steel.

Which side of the belt should run next to the pulley.

The proper speed of line shafts.

The right way to lace belts.

Whether compression is economical or the reverse.

The principle of the steam injector.

THINGS WORTH KNOWING.

Dominer has discovered that bronze is rendered malleable by adding to it from one-half to two per cent. of mercury.

An "inch of rain" means a gallon of water spread over a surface of nearly two square feet, or a fall of about 100 tons on an acre of ground.

A steam power plant is divided into five fundamental parts by a French author — the boiler, motor, condenser, distributing mechanism, and mechanism of transmission.

Turpentine and black varnish, put with any good stove polish, is the blackening used by hardware dealers for polishing heating stoves. If properly put on, it will last throughout the season.

A workman in the Carson mint has discovered that drill points, heated to a cherry-red and tempered by being driven into a bar of lead, will bore through the hardest steel or plate glass without perceptibly blunting.

To harden copper, melt together; and stir till thoroughly incorporated, copper and from one to six per cent. of mandganese oxide. The other ingredients for bronze and other alloys may then be added. The copper becomes homogeneous, harder and tougher.

SIMPLE TESTS FOR WATER.

Boiler-users who desire simple tests for the water they are using will find the following compilation of tests both useful and valuable:

Test for Hard or Soft Water—Dissolve a small piece of good soap in alcohol. Let a few drops of the solution fall into a glass of the water. If it turns milky, it is hard water; if it remains clear, it is soft water.

Test for Earthy Matters or Alkali—Take litmus-paper dipped in vinegar, and, if on immersion the paper returns to its true shade, the water does not contain earthy matter or alkali. If a few drops of syrup be added to a water containing an earthy matter, it will turn green.

Test for Carbonic Acid—Take equal parts of water and clear lime water. If combined or free carbonic acid is present, a precipitate is seen, to which, if a few drops of muriatic acid be added, effervescence commences.

Test for Magnesia—Boil the water to twentieth part of its weight, and then drop a few grains of neutral carbonate of ammonia into a glass of it and a few drops of phosphate of soda. If magnesia is present, it will fall to the bottom.

Test for Iron—Boil a little nut-gall and add to the water. If it turns gray or slate-black, iron is present. Second: Dissolve a little prussiate of potash, and, if iron is present, it will turn blue.

Test for Lime—Into a glass of water put two drops of oxalic acid, and blow upon it. If it gets milky, lime is present

Test for Acid—Take a piece of litmus-paper. If it turns red, there must be acid. If it precipitates on adding lime water, it is carbonic acid. If a blue sugar paper is turned red, it is a mineral acid.

Test for Copper—If present, it will turn bright polished steel a copper color. Second: A few drops of ammonia will turn it blue, if copper is present.

Tests for Lead—Take sulphureted gas and water in equal quantity to be tested. If it contains lead, it will turn a blackish brown. Again: The same result will take place if sulphate of ammonia be used.

Test for Sulphur—In a bottle of water add a little quicksilver, cork it for six hours, and, if it looks dark on the top, and on shaking looks blackish, it proves the presence of sulphur.

JAPANESE LACQUER FOR IRON SHIPS.

The Japanese Admiralty has finally decided upon coating the bottoms of all their ships with a material closely akin to the lacquer to which we are so much accustomed as a specialty of Japanese furniture work. Although the preparation differs somewhat from that commonly known as Japanese lacquer, the base of it is the same—viz., gum-lac, as it is commonly termed. Experiments, which have been long continued by the Imperial Naval Department, have resulted in affording proof that the new coating material remains fully efficient for three years, and the report on the subject demonstrates that, although the first cost of the material is three times the amount of that hitherto employed, the number of dockings required will be reduced by its use to the proportion of one to six. A vessel of the Russian Pacific fleet has already been coated with the new preparation, which, the authorities say, completely withstands the fouling influences so common in tropical waters. It took the native inventor many years to overcome the tendency of the lac to harden and crack; but having successfully accomplished this, the finely-polished surface of the mixture resists in an almost perfect degree the liability of barnacles to adhere or weeds to

grow, while, presumably, the same high polish must materially reduce the skin friction which is so important an element affecting the speed of iron ships. The dealers in gum-lac express the fear lest the demand likely to follow on this novel application of it may rapidly exhaust existing sources of supply.

IRON IN THE CONGO.

Recently Mr. Dupont, director of the Museum of Natural History of Brussels, went to the Congo for the purpose of studying the geology of the valley from the Atlantic to the confluence of the Kassai River, over 400 miles from the coast. After eight months devoted to this work, he has returned to Europe, bringing some surprising reports with regard to the mineral resources of the region. He says that throughout the entire extent of the country he found in the plateaus skirting the river, under the thick alluvium, a stratum of iron ore from a foot and a half to three feet in thickness. In numerous places he saw blocks of iron ore sometimes many cubic feet in dimensions, upon the slopes of ravines, where they had been exposed by denudation. He asserts that there is scarcely a country in the world so rich in iron ore as the Congo basin, and the mineral is not only abundant, but can also be easily reduced. In his opinion, if the other continents ever exhaust their resources of iron, the Congo basin can supply the rest of the world for a long period.

GLASS CUTTING BY ELECTRICITY.

The cutting of glass tubes of wide diameter is another of the almost innumerable industrial applications of electricity. The tube is surrounded with fine wire, and the extremities of the latter are put in communication with a source of electricity, and it is of course necessary that the wire adhere closely to the glass. When a current is passed through the wire, the latter becomes red hot and heats the glass beneath it, and a single drop of water deposited on the heated place, will cause a clean breakage of the glass at that point. Contrary to what takes place with the usual processes in the treatment of this frangible material, it is found that, the thicker the sides of the tubes are, the better the experiment succeeds.

Glass, as far as research has been able to determine, was in use 2,000 years before the birth of Christ, and was even then not in its infancy.

DEAFNESS CAUSED BY THE ELECTRIC LIGHT.

A curious phenomenon was recently related by M. D'Ar sonval before the French Academy of Medicine. After gazing for a few seconds on an arc light of intense brilliancy, he suddenly became deaf, and remained so for nearly an hour and a half. Surprised, and somewhat alarmed in the first instance, but reassured by the disappearance of the symptoms, he repeated the experiment with the same result. When only one eye was exposed to the light, no very marked effect was produced.

BROWNING GUN BARRELS.

Mix 16 parts sweet spirits niter, 12 parts saturated solution of sulphate of iron, 12 parts chloride of antimony. Bottle and cork the mixture for a day, then add 500 parts of water and thoroughly mix. Clean the barrel to a uniform grain free from grease and finger stains. Wipe with a staining mixture on a wad of cotton. Let it stand for twenty-four hours, scratch brush the surface and repeat twice. Rub off the last time with leather moistened with olive oil. Let dry a day, and rub down with a cloth moistened with oil to polish.

SPONTANEOUS COMBUSTION

There is a remarkable tendency observable in tissues and cotton, when moistened with oil, to become heated when oxidation sets in, and sad results often follow when this is neglected. A wad of cotton used for rubbing a painting has been known to take fire when thrown through the air. The waste from vulcanized rubber, when thrown in a damp condition into a pile, takes fire spontaneously. Masses of coal stored in a yard have been known to take fire without a spark being applied, and one cannot be too careful in storing any substance in which oxidation is liable to take place.

A LARGE LUMP OF COAL.

One of the largest lumps of coal ever mined in the Monongahela Valley was taken from J. S. Neels' Cincinnati mines, near Monongahela City, lately. The block measured 7 feet 8 inches long, 3 feet 5 inches high, and 3 feet 7 inches wide. A temporary track was laid to the river, and the big piece of al loaded in a boat for Cincinnati.

SCREW-MAKING AT PROVIDENCE, RHODE ISLAND.

It is not known when screws were first made and brought into use. The first instance known of machinery being applied to the making of screws, was in France, in 1569, by a man named Besson, who contrived a screw-cutting gauge to be used in a lathe. The early method had been to make the heads by pinching the blanks while red hot between dies, and then to form the threads by the process of filing. In 1741 Besson's device was improved by Hindley, a watchmaker, of York, England; and for a long time the watch-makers of that country used this device in making the small screws used in their work. The first English patent appears to have been issued to Job and William Wyatt, in 1760, for three machines —one for making blanks, another for nicking the heads, and a third for cutting the threads. Between that date and 1840 about ten patents were issued, only one of which is worthy of notice, namely that of Miles Berry, dated January 28, 1837, which was for a gimlet-pointed screw. The first American patent was issued December 14, 1798, to David Wilkinson, a celebrated mechanic of Rhode Island. The next American patent was dated March 23, 1813, and was issued to Jacob Perkins, of Newburyport, Mass. In that year, also, a patent was granted to Jacob Sloat, of Ramapo, N. Y. At the extensive nail and iron works of the Piersons, established in Ramapo in 1798, Thomas W. Harvey in 1831 applied the toggle-joint to the headings of screws, rivets and spikes. In 1834 Mr. Harvey entered into partnership with Frederick Goodell, a cotton manufacturer of Ramapo, and established a small screw manufactory at Poughkeepsie, and early in the next year Mr. Harvey invented machines for heading, nicking and shaving screws. These and a thread-cutting machine, purchased from its inventors, Jacob Sloat and Thomas Springsteen, were successfully operated, producing a gimlet-pointed screw.

It is interesting to note that, while the manufacture of wood screws probably originated in Westphalia, Germany, and was subsequently carried on in eastern France and England before its introduction into this country, American inventors have supplied the machinery that is now universally employed. The popular feeling that the gimlet-pointed screw was a modern invention is erroneous. The company has in its possession sample cards of French screws, pointed, though

not as perfectly made as at present, which were brought from France early in the present century, and from an old piano now at Northampton, made about the year 1750, screws have been taken showing the same feature. Patents have been issued on gimlet-pointed screws, but they covered only a peculiar form of point.

The Eagle Mill of the American Screw Company is devoted to the manufacture of wood screws. In the yard connected with this mill are landed the rods, in coils, from which the screws are to be manufactured. The larger portion of these rods is imported from Sweden, Germany and England. The first room into which the reader is to be conducted is the "pickling room." Here the rod is "pickled" for the purpose of removing the flinty scale on the outside; and the action of the mixture in that process tends to facilitate the drawing of the wire. After being annealed in furnaces the wire is subjected to the pointing process, the purpose of which is to reduce the end of the rod to enter the draw-plate. The wire is taken into the drawing room, where it is drawn in different sizes needed for the great variety of screws. The machinery for the different processes is the result of the skill of many inventors, who have produced a system of machines mostly automatic and beautiful in operation. By the automatic wire block used, if anything happens to the wire while going through the process, the whole apparatus stops. If it did not stop, the wire would break. By a machine, whose action is accurate and fascinating, the rod is cut into the sizes of the screws desired and the head put on almost at the same instant. The metal, in going through this process, necessarily becomes very oily. These "blanks," for such they are called at this stage of their manufacture, are put into what are called "rattlers," revolving boxes, hexagonal in shape, filled with saw dust, where they are cleansed of the oil that covers them, the oil being absorbsed by the sawdust. The blanks are ready to have their heads "shaved," which consists in cutting the heads perfectly round. The blanks are put into a hopper, and by an automatic feeder they are let down into a trough, from which they are picked by a metal finger and put into a spindle. The heads are then "shaved," and by a revolving spindle the blank is taken to the small saw which cuts the slot in the head. The blank is then revolved back again and shaved again, to get rid of the "burr," or the rough edge left by the tool, in cutting the slot. The blanks are then fired out of the machine absolutely perfect. The machine is an automatic

but very complicated one; every part of it, however, does its work effectively. The blanks, after being shaved and slotted, are placed in another machine and threaded, when the screw is complete.

HOW THERMOMETERS ARE MADE.

The first point, in the construction of the mercurial thermometer, is to see that the tube is of uniform caliber throughout its whole interior. To ascertain this, a short column of mercury is put into the tube and moved up and down, to see if its length remains the same through all parts of the tube. If a tube whose caliber is not uniform is used, slight differences are made in its graduation to allow for this. A scale of equal parts is etched upon the tube; and from observations of the inequalities of the column of mercury moved in it, a table giving the temperatures corresponding to these divisions is formed. A bulb is now blown on the tube, and while the open end of the latter is dipped into mercury, heat is applied to the bulb to expand the air in it. This heat is then withdrawn, and the air within contracting, a portion of the mercury rises in the tube, and partly fills the bulb. To the open end of the bulb a funnel containing mercury is fitted, and the bulb is placed over a flame until it boils, thus expelling all air and moisture from the instrument. On cooling, the tube instantly fills with mercury. The bulb is now placed in some hot fluid, causing the mercury within it to expand and flow over the top of the tube, and, when this overflow has ceased, the open end of the tube is heated with a blow-pipe flame. To graduate the instrument, the bulb is placed in melting ice; and, when the top of the mercury column has fallen as low as it will, note is taken of its position as compared with the scale on the tube. This is the freezing point. It is marked as zero on the thermometers of Celsius and Reaumur, and as 32° on the Fahrenheit class.

To determine the boiling point, the instrument is placed in a metallic vessel with double walls, between which circulates the steam from boiling water. Between the freezing and boiling point of water, 100 equal degrees are marked in the centigrade graduation of Celsius, 180° on the Fahrenheit plan, and 80° on the Reaumur. In many thermometers, all three of these graduations are indicated on the frame to which the tube is attached. Some weeks after a thermometer has been made and regulated, it may be noticed that, when the bulb is immersed in pounded ice, the mercury does not quite descend to the freezing point. This is owing to a gradual expansion of the mercury, which usually goes on for nearly

two years, when it is found that the zero point has risen nearly a whole degree. It is then necessary to slide down the scale to which the tube is fastened, so that it will accurately read the movements of the mercury. After this change, the accuracy of the thermometer is assured, as there is no further expansion of the mercury column.

POINTS FOR APPRENTICES.

In starting to learn a trade as an apprentice, first imagine yourself brighter, and more apt to learn, than the older apprentices in the shop. Criticise their work on the last range they blacked. Show the red spots under the doors or under the top plates, and if you are not dropped through the trap door into the cellar the first opportunity they get, it will be some good fortune that favors you. When working with a jour., tell him how Tom Jones does that, and his ways are not right, or tell him how to do it. Of course the jour. has worked fifteen years at the business, but that doesn't make any difference, you go ahead. If he does not call you cuss words and tell you to mind your business, he must have a mother-in-law who comes over to see him seven times a day, and stays all day Sunday.

When you have worked about a year at the business, and you think you are competent to take charge of the shop, and you are given a job of cleaning a furnace, which, of course, will smut a boiled shirt, you go home, and kick to the old folks; say you are not going to work for Smith any more, as he gives you all the dirty work to do, and get the old folks to go around and see Smith about their precious boy. It will make you, in the eyes of Smith, as large as Jumbo to a rat.

When you worry your term of apprenticeship through and you receive the title of jour., of course you demand jour.'s wages, say as much as old man Stewpot. He has worked eighteen years in the shop, but that doesn't matter. Why, you made six dozen joints of stove pipe in two hours and it took him three! Well, if you don't make satisfactory arrangements, I heard Billy Doepan say that Enos Kettle, at Inkville, wanted a man, and you, of course, strike; it pays big wages to a first-class man. You go and see Kettle and he asks you what you can do. Of course you worked on the cornice for the Grand Opera House, and on the button factory, and several other jobs too numerous to mention. You receive a position to help Kettle out on the Green building cornice. This being Thursday night, and he has to go to Plumtown to finish up a job, he would like to have you come on in the morning. He

gives you a simple piece of cutting to keep you going until his return on Saturday night, when he makes a practice of paying off his help. You come under this head, and find that he offers you the enormous sum of seventy-five cents per day, and orders the stove porter to go and cover the pig trough with your two days' work to keep the pigs from making post holes in their trough, which his wife wanted him to do for the past nine months. You declare he is a crank; you are going West, or to some seaport town.

You strike out and get a position in a roofing shop painting tin. You write home to your brother chip telling what a position you have, what big wages, etc., but not giving original facts. In a few years you return home broken down, with no trade. You can't demand a mechanic's wages, and you look back and see your folly. How many are there in this boat? Boys, take my advice: Don't get to knowing too much. If you get into that way, it is little use for a mechanic to have anything to do with you.

THREE THERMOMETER SCALES.

Much annoyance is caused by the great difference in thermometer scales in use in the different civilized countries. The scale of Reaumur prevails in Germany. As is well known, he divides the space between the freezing and boiling points into 80°. France uses that of Celsius, who graduated his scale on the decimal system. The most peculiar scale of all, however, is that of Fahrenheit, a renowned German physicist, who in 1714 or 1715 composed his scale, having ascertained that water can be cooled under the freezing point without congealing. He therefore did not take the congealing point of water, which is uncertain, but composed a mixture of equal parts of snow and salammonia, about—14° R. This scale is preferable to both those of Reaumur and Celsius, or, as it is called, Centigrade, because: 1. The regular temperatures of the moderate zone move within its two zeros, and can therefore be written without + or —. 2. The scale is divided so finely that it is not necessary to use fractions, when careful observations are to be made. These advantages, although drawn into question by some, have been considered so weighty, that both Great Britain and America have retained the scales, while the nations of the Continent use the other two. The conversion of any one of these scales into another is very simple. 1. To change a temperature given by Fahrenheit's scale into the same given by the Centigrade scale, subtract 32° from Fahrenheit's degrees and multiply

the remainder by $\frac{5}{9}$. The product will be the temperature in Centigrade degrees. To change from Fahrenheit's to Reaumur's scale, subtract 32° from Fahrenheit's degrees, and multiply the remainder by $\frac{4}{9}$. The product will be the temperature in Reaumur's degrees. 3. To change a temperature given by the Centigrade scale into the same given by Fahrenheit, multiply the Centigrade degrees by $\frac{9}{5}$, and add 32° to the product. The sum will be the temperature by Fahrenheit's scale. 4. To change from Reaumur's to Fahrenheit's scale, multiply the degrees on Reaumur's scale by $\frac{9}{4}$, and add 32° to the product. The sum will be the temperature by Fahrenheit's scale. Following is a table giving the equivalents in Centigrade, Reaumur and Fahrenheit, up to boiling point, which will be a convenience to all readers who do not like the labor of converting one scale to another:

C.	R.	F.	C.	R.	F.
—30	—24.0	—22.0	—1	—0.8	30.2
—29	—23.2	—20.2	0	0.0	32.0
—28	—22.4	—18.4	1	0.8	33.8
—27	—21.6	—16.6	2	1.6	35.6
—26	—20.8	—14.8	3	2.4	37.4
—25	—20.0	—13.0	4	3.2	39.2
—24	—19.2	—11.2	5	4.0	41.0
—23	—18.4	—9.4	6	4.8	42.8
—22	—17.6	—7.6	7	5.6	44.6
—21	—16.8	—5.8	8	6.4	46.4
—20	—16.0	—4.0	9	7.2	48.2
—19	—15.2	—2.2	10	8.0	50.0
—18	—14.4	—0.4	11	8.8	51.8
—17	—13.6	1.4	12	9.6	53.6
—16	—12.8	3.2	13	10.4	55.4
—15	—12.0	5.0	14	11.2	57.2
—14	—11.2	6.8	15	12.0	59.0
—13	—10.4	8.6	16	12.8	60.8
—12	—9.6	10.4	17	13.6	62.6
—11	—8.8	12.2	18	14.4	64.4
—10	—8.0	14.0	19	15.2	66.2
—9	—7.2	15.8	20	16.0	68.0
—8	—6.4	17.6	21	16.8	69.8
—7	—5.6	19.4	22	17.6	71.6
—6	—4.8	21.2	23	18.4	73.4
—5	—4.0	23.0	24	19.2	75.2
—4	—3.2	24.8	25	20.0	77.0
—3	—2.4	26.6	26	20.8	78.8
—2	—1.6	28.4	27	21.6	80.6

C.	R.	F.	C.	R.	F.
28	22.4	82.4	65	52.0	149.0
29	23.2	81.2	66	52.8	150.8
30	24.0	86.0	67	53.6	152.6
31	24.8	87.8	68	54.4	154.4
32	25.6	89.6	69	55.2	156.2
33	26.4	91.4	70	56.0	158.0
34	27.2	93.2	71	56.8	159.8
35	28.0	95.0	72	57.6	161.6
36	28.8	96.8	73	58.4	163.4
37	29.6	98.6	74	59.2	165.2
38	30.4	100.4	75	60.0	167.0
39	31.2	102.2	76	60.8	168.8
40	32.0	104.0	77	61.6	170.6
41	32.8	105.8	78	62.4	172.4
42	33.6	107.6	79	63.2	174.2
43	34.4	109.4	80	64.0	176.0
44	35.2	111.2	81	64.8	177.8
45	36.0	113.0	82	65.6	179.6
46	36.8	114.8	83	66.4	181.4
47	37.6	116.6	84	67.2	183.2
48	38.4	118.4	85	68.0	185.0
49	39.2	120.2	86	68.8	186.8
50	40.0	122.0	87	69.6	188.6
51	40.8	123.8	88	70.4	190.4
52	41.6	125.6	89	71.2	192.2
53	42.4	127.4	90	72.0	194.0
54	43.2	129.2	91	72.8	195.8
55	44.0	131.0	92	73.6	197.6
56	44.8	132.8	93	74.4	199.4
57	45.6	134.6	94	75.2	201.2
58	46.4	136.4	95	76.0	203.0
59	47.2	138.2	96	76.8	204.8
60	48.0	140.0	97	77.6	206.6
61	48.8	141.8	98	78.4	208.4
62	49.6	143.6	98	79.2	210.2
63	50.4	145.4	100	80.0	212.0
64	51.2	147.2			

WHY STEEL IS HARD TO WELD.

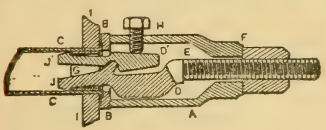
A metallurgist gives, as a reason why steel will not weld as readily as wrought iron, that it is not partially composed of cinder, as seems to be the case with wrought iron, which assists in forming a fusible alloy with the scale of oxidation on the surface of the iron in the furnace.

DIFFERENT COLORS OF IRON, CAUSED BY HEAT.

Deg. Cen.	Deg. Fah.	
261 370	502 680	Violet, purple and dull blue. Between 261° C. to 370° C. it passes to bright blue sea green, and then disappears.
500	932	Commences to be covered with a light coating of oxide; becomes a deal more impressible to the hammer, and can be twisted with ease.
525	977	Becomes a nascent red.
700	1292	Somber red.
800	1472	Nascent cherry.
900	1657	Cherry.
1000	1832	Bright cherry.
1100	2012	Dull orange.
1200	2192	Bright orange.
1300	2372	White.
1400	2552	Brilliant white-welding heat.
1500 1600	2732 2912	Dazzling white.

TO DRAW FERRULES.

A useful tool for drawing thimbles or ferrules out of locomotive boiler tubes is here shown. It is an English invention, and it is not stated that it is patented. The tube *A* is split in quarters on the end so that it can be easily slipped in. The rest of the device explains itself, as does the second figure also, which is another device for the same purpose.



BELTING SHAFTING AT RIGHT ANGLES

In Fig. 1 of the illustration, *A* is the driver. The belt leaves the pulley at *C*, goes to the driven pulley, and then down to the driver at *h*. In Fig. 2 this movement is re-

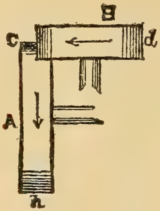


Fig. 1.

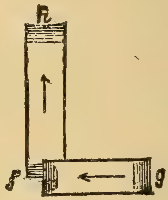
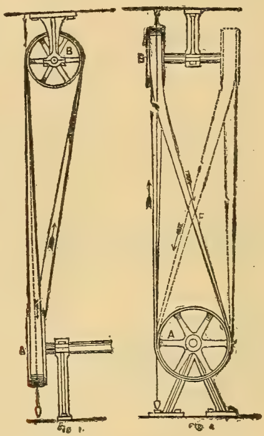


Fig. 2.

versed. Fig. 3 is a side view of the driven pulley *B*, and Fig. 4 shows the driving pulley *A*, with the driven pulley *B* inside, so as to run in the one direction, while the dotted lines

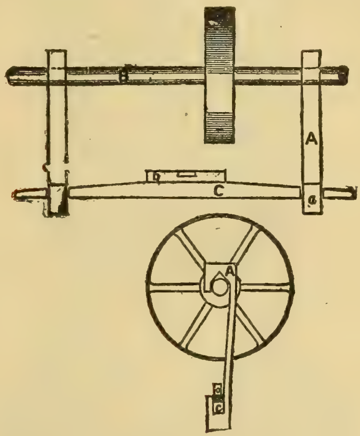


show *B* outside, so as to run the opposite way. Figs. 1 and 2 show that centers of the faces of both pulleys must be in line

with each other, and if this point is attended to the pulleys will run well together, although they may be of different diameter.

AN EASY WAY TO LEVEL SHAFTING.

The device here illustrated for leveling shafting I have found to be very handy. The hangers *A* are made of wood and are cut at an angle of 45° at the top end, so that they will fit different sized shafts, and a slot is cut at (*a*) to receive the straight edge *C*. The hangers are placed on the shaft to be

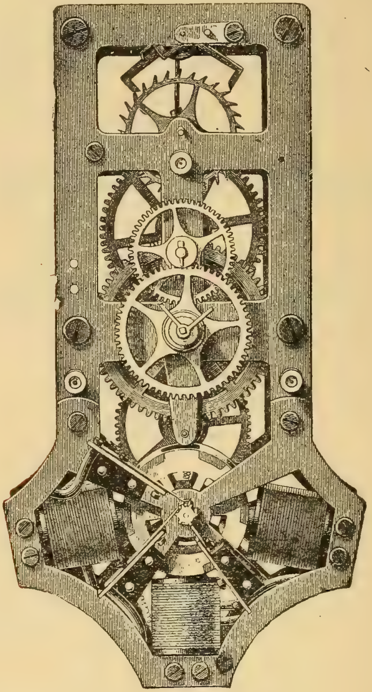


tried, at any convenient place as near the bearings as possible, and the straight edge placed in the slots, in which it should fit tight. Then by placing the spirit level *D* on the parallel part of the straight edge, it will be seen whether the shaft is level or not. It is best if the hangers be made of hard wood.

A SELF-WINDING CLOCK MOVEMENT.

A self-winding clock is now on the market and we present herewith an engraving of one. It is made by the American Manufacturing and Supply Co., Limited, 10 and 12 Dey street, New York. Objection may be made to the employment of a battery as an auxiliary, and therefore that the clock

is not self-winding, but the office of the battery is secondary, the operation of the clock opening the circuit while the battery is used only to interrupt it. Appended is a description of the movement:



The wheels and arbors below the center are removed from the clock. In their place a small electric motor is substituted. This motor connects with a spring barrel on the center arbor, which incloses a spring six feet long, three-sixteenths of an inch in width and six-one-thousandths of an inch in thickness. This spring, at its inner end, is attached

to the arbor, and at the outer end to the periphery of the spring barrel. The spring is coiled around the arbor many times, but not so close as to produce friction between the coils; and being attached to the center arbor it follows that the inner end will unwind one turn every hour. By a simple attachment the electric circuit is made to pass into the motor already referred to, which quickly carries the spring barrel around once (being free on the arbor), and the outer end of the spring attached to its periphery with it. Upon the completion of one revolution of the spring barrel, as described, the electric circuit is broken and the motor stops. By this arrangement it will be observed that the inner end of the spring always has a motion from left to right, or in the direction the hands are moving, and the outer end of the spring a motion in the same direction when the clock is being wound.

Now, since the winding is done in the same direction as the unwinding of the inner end, and the spring is so wound originally as to avoid friction between the coils, it follows that the tension upon the train is absolutely uniform at all times whether the outer end of the spring is at a point of temporary rest or is being carried around the arbor at the time of winding, as above described. By actual experiment it is found that to obtain a given force at the escape wheel it is only necessary to apply a power in this manner at the center arbor equal to less than one forty-sixth part of that used in the ordinary clock. The train work is not only shortened one-half, but the friction on the remainder is reduced in the proportion stated.

The invention lies in bringing a motor and clock-work together in a time piece, and is not limited to any particular device. Experiments prove that a motor as constructed for this purpose can be run for one year at an expense of less than twenty-five cents; hence a clock may be sealed up and left to itself for a period of at least one year with a certainty of closer time during that period than can be secured by any other known method of giving time. In short, a common clock constructed on this principle has been found to keep as accurate time as one of the higher grades with gravity escapements, etc., run by the old methods. The electric motor is normally out of circuit, but at stated intervals, by the operation of the clock itself, the circuit is completed and the motor is thus set in motion. To be more exact we will give a general description of the mechanism employed in the clock. Upon the center arbor there is placed a loose "arm" between the hour wheel and the wheel carrying the spring

box. At one side of one of the "train plates" is secured an insulated spring connector, the free end of which extends to, and is within reach of, the "arm," when the same has been brought to a perpendicular position, which is done by means of a pin projecting from the hour wheel.

When the hour wheel has thus brought the "arm" to an upright position and in contact with the insulated spring connector, the circuit is completed through the motor, which at once commences to rotate the spring box one revolution from left to right, or in the direction that the hands move. The spring box wheel also carries a projecting pin, but set at a less distance from the axis than the other pin. Now, as the motor continues to rotate, the spring box wheel, while the spring connector is resting upon the "arm," it follows that as soon as there has been one revolution of the spring box wheel the projecting pin upon this wheel will press the "arm" forward and out from under the spring connector, thereby breaking the circuit and stopping the motor. This arrangement prevents the possibility of the clock running beyond the regular limit for winding, and prevents the motor when once set in operation from performing more than the work required.

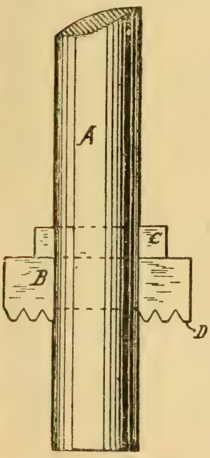
TESTS OF STEEL PIPE.

The Riverside Iron Works, of Wheeling, W. Va., has carried out a series of interesting experiments to ascertain the relative corrosive action of water acidulated with nitric acid upon iron and steel plates cut from pipe. The water was acidulated with one part of strong nitric acid in ninety parts, the plates being of the same dimensions, free from scale and grease and polished bright. In each case the pieces cut from iron and steel pipe were hung side by side in the same acidulated water, the loss of weight being determined at the end of twenty-four and of forty-eight hours. One test was made by exposing both surfaces and edges to the action of dilute acid, the result being that the loss in grains after twenty-four hours was 3.6 in the case of iron from standard iron pipe, and 1.15, or less than half, with steel pipe. In forty-eight hours the figures stood 6.53 and 2.21 grains, respectively. In a second test the edges of the pieces were protected from the action of the acid and the two opposite sides only exposed. In this test the loss of iron after twenty-four hours was 1.89 grains, against 0.49 grains with the steel, and after forty-eight hours 4.28 and 1.24, respectively. The dimensions of the test-pieces were 1¼ inches

square by 3-16-inch thick. A series of comparative tests have also been made to ascertain the relative strength of the weld of Riverside steel and standard iron pipe. Two test-pieces were cut from Riverside pipe, mechanically lap-weld, with the weld at the middle, and in a similar way from mechanical lap-welded iron pipe, in each case with the weld in the middle. Not one of the tests broke at the weld, the steel showing a tensile strength of 52,400 and 66,330 pounds, with an elongation of 18.75 and 17.25 per cent. in 8 inches, while the iron pipe samples showed 62,480 and 35,240 pounds per square inch, and an elongation of 2.25 and 0.50 per cent Two samples from a sheet of Riverside steel lap-welded by hand, with the weld in the middle, showed a tensile strength of 51,860 pounds, and an elongation of 7 per cent. in 8 inches, the fracture occurring at the weld. A second sample had an ultimate strength of 56,090 pounds, elongation 13 per cent, and did not break at the weld. Iron plates cut with the grain and hand-welded have a tensile strength of 44,630 and 43,500 pounds, respectively, with an elongation of 5 and 4.25 per cent., both breaking at the weld.

TOOL FOR COUNTER-BORING.

The above is a sketch of a tool that will be found very convenient on many occasions, when counter-boring work in the drill press; usually such work is done with a cutter of the same shape as it is desired to have the finished work, when if there is any scale, as in cast iron, it is very difficult to get the cutter started. The tool in the sketch entirely obviates that difficulty, as only the points come in contact with the scale at first and are easily forced through it. Referring to the sketch, *A* is the end of a cutter-bar, *B*, the cutter, and *C*, the wedge for keeping the cutter in place. It will be noticed that the teeth *D*, on one side of the bar will, as it is revolved, cover the space left by the part of the cutter on the other side of the bar, and thus rapidly remove the scale and metal, when the work may be finished by the ordinary flat cutter.



HOW TO MAKE A SMALL STORAGE BATTERY.

A storage battery, or accumulator, to light an incandescent lamp of 4 candle-power, would not go in an ordinary sized pocket, because one would require at least *four* cells, and if the plates were made too small, the charge put into them would last scarcely a few seconds. The following directions will enable any person to construct a storage battery, which, when charged, will light a 4-volt lamp.

The first thing to do is to procure of some dealer in electrical apparatus and material a hard rubber cell, about 3½ inches by 5 inches by 1 inch, having two compartments of equal dimensions. Such a cell can be purchased for about fifty cents.

Next, cut four plates from one-sixteenth inch sheet lead, 4½ inches by 1¼ inch, having an ear to each; punch as many holes in each plate as you can to within ¾ inch from the ear or top end. Then fill up the holes, and also smear the plates with a thick paste of red lead (minimum) and diluted sulphuric acid. Cut out a piece from thin — ⅛ of an inch — hard wood, 3½ inches long and 1 inch wide; pierce it with four slits large enough to allow the ears of the plates to come through (two to each cell), and, also, where convenient, two holes should be made and fitted with glass tubes for the purpose of filling the cells.

As soon as the red lead paste has become hard, plac thee four plates in their positions, and solder the ear of one plate to the ear piece of the next cell. This will leave one free end from each cell; to these a wire or terminal should be soldered. Now cement on the top and cover all over, except the glass tubes, with a composition of one part melted pitch and two parts of gutta-percha.

Having filled the cells three-quarters full with a 10 per cent. solution of sulphuric acid, connect the wires on a primary battery or small dynamo. Charge, discharge and reverse every three hours, and let the last charge remain in all night. Do this till you find your storage battery will ring a bell, with fifteen minutes' charging, for about ten. Then only charge one way, and mark the ends in some way so as to know where to connect one next time for charging.

This battery, when completed, will light a 3 or 4 volt lamp well during intervals for about two hours. A similar cell, having four compartments instead of two, would suffice to operate an 8 or 9 volt lamp, or one of about 6 candle-power.

Such a battery as has just been described may be

veniently be formed by a ten-cell Daniel telegraph battery in about a fortnight's time.

A storage battery of this size should never be charged until within an hour or so of its being wanted for use, as it will run down a little by short circuiting, owing to the dampness of the inside.

Finally, it should be stated, that, before putting the plates in the cells for good, a piece of india rubber ought to be placed between the plates, as well as a piece on the two outsides, and held by a piece of asbestos fiber. This prevents the plates from touching each other, and also keeps them from shaking from side to side.

LUBRICATING WITHOUT OIL.

Several interesting facts in regard to cylinder lubrication were brought out at the recent meeting of the American Society of Mechanical Engineers, at Philadelphia. Among other things Mr. Denton stated as his opinion that the friction of an engine was independent of the lead, and, among other things, presented the subjoined interesting table:

Indicated H. P.	Friction, H. P.	Kind of engine.
84	7	Westinghouse, 12x11 inches, 300 revolut's.
Unloaded	10	
23	5	Buckeye, 7x14 inches, 280 revolutions.
Unloaded	5.1	
347	44	Compound condensing throttled.
185	40	
181	19	Compound condensing expansion.
137	25	

This table, it will be observed, shows that the friction is actually less in all cases but one when the load is greatest. Mr. Denton thought that the friction of a piston in a cylinder was slight, and that lubrication did not bring about any noticeable result so far as this particular part was concerned. In support of these statements he cited first the case of an engine in which the steam of the same pressure was admitted to both cylinder ends at the same time The difference in area between the two faces of the piston, owing to the presence of the piston-rod, and the consequently greater effective

pressure on the back, as compared with the front face. caused the piston to move slowly to the front end of the cylinder. The friction, therefore, could not have been appreciable. As regards lubrication Mr. Denton gave an account of his experience with engines which had been cleaned out with ether, and in which no oil whatever had been used for months. The records obtained under such conditions, when compared with data from the same engines using oil in the cylinders, showed no difference worthy of special note. The fact that engines showed less friction under the heavier loads than under the lighter ones Mr. Denton explained by the assumption that the various journals, through the reversal of motion of the reciprocating parts of the engines, developed a suction-pump action, drawing in the lubricating oil, and that this action was more vigorous when the engines were fully loaded.

CALKING.

Calking is something that is not always done as it should be. In fact, in some sections of the country it is done as it shouldn't be, about as emphatically as it is possible to do anything. The thing most particularly referred to in this connection, and the practice of which should bankrupt any boilermaker, is known as "split calking." To do calking in the best manner, and as it should be done, the edges of the plates should be planed. They are planed in all first-class shops, and trouble caused by bad calking is something very rare with such work. But of course this refers to new work. Repair jobs, and boiler work turned out of the shops in remote sections of the country where planers are unknown, afford the demon of split calking a chance to get in his most effective work. He rarely neglects a chance that is offered him Some one may inquire, what is split calking? To which we would reply, split calking consists in driving a thin caulking tool, scarcely one-sixteenth of an inch thick, against the edge of a sheet so that a thin section of the plate is driven in between the two plates, with the idea of making a joint tight. The result generally is that the plates are separated from the edge of the lap back to the line of rivets, sometimes as much as one-thirty-second of an inch, the only bearing surface outside of the rivets being the portion split off from the plate and driven in by the calking tool. This bearing surface may be an eighth of an inch wide, but it is apt to be much less, and no patent medicine yet discovered will keep the seam tight for any length of time. When a boiler thus calked gets to leaking so badly that it can't be

run, the boiler-maker is sent for, and he usually proceeds to do more split calking, and in a short time the boiler leaks worse than ever. In one instance one of our inspectors examined a boiler and found one of the girth seams leaking badly. It had repeatedly been calked in the above manner; so many times, in fact, had the process been repeated, that there was not enough of the lap to perform another operation on. He, therefore, gave instructions for putting on a patch, with a special caution to the owner, to whom he explained the cause of the trouble, to allow no split calking to be done on it. On his next visit he examined the patch, and he declares that the boiler-maker had put in on it the worst job of split calking he ever saw in his life.

USEFUL NUMBERS.

3.1415926=ratio of diameter to circumference of circle.

.7854=ratio of area of circle to square of its diameter.

33,000 minute foot pounds=1 HP.

396,000 minute inch pounds=1 HP.

396,000 cubic inches piston displacement per minute of engine wheel would develop 1 HP. with 1 lb. mean effective pressure on the piston.

23,760,000 cubic inches piston displacement per hour of engine developing 1 HP. with 1 lb. mean effective pressure on the piston.

859,375 pounds of water per hour at 1 lb. pressure per square inch to give 1 HP.

55 lbs. mean effective pressure at 600 feet piston speed gives 1 HP. for each square inch of piston area.

0.301030=	natural	logarithm	2.
0.477121	"	"	3.
0.602060	"	"	4.
0.698970	"	"	5.
0.778151	"	"	6.
0.845098	"	"	7.
0.903090	"	"	8.
0.954243	"	"	9.
1.000000	"	"	10.

2.3025851 times natural logarithm gives hyperbolic logarithm.

.5000000=	sine of	30°	with radius	1.
.7071068	"	45°	"	1.
.8660254	"	60°	"	1.

9,000 to 13,000 feet per minute velocity of circular saw rim.

27,000 lbs. per square inch tensile strength of cast iron.

50,000 lbs. per square inch tensile strength of wrought iron.

120,000 lbs. tensile strength of steel.

30,000 lbs. tensile strength of sheet copper.

60,000 lbs. tensile strength of copper wire.

100,000 lbs. per square inch=crushing strength of cast iron.

35,000 lbs. per square inch=crushing strength of wrought iron.

225,000 lbs. crushing strength of steel.

300 to 1,200 tons per square foot crushing strength of granite.

6,500 lbs. per square inch crushing strength of oak.

(Above crushing strengths are for pieces not over 3 diameters in length.)

600 to 1,000 feet per minute of single leather belt 1 inch wide said to give 1 HP. on cast iron pulleys.

2.645 lbs. per lineal foot of 1 inch round wrought iron.

3.368 lbs. per lineal foot of 1 inch square wrought iron.

40 lbs. per square foot of 1 inch plate wrought iron.

2.45 lbs. per lineal foot of 1 inch round cast iron.

12 times weight of pine pattern = iron casting.

13 times weight of pine pattern = brass casting.

19 times weight of pine pattern = lead casting.

12.2 times weight of pine pattern = tin casting.

11.4 times weight of pine pattern = zinc casting.

.06363 times square of inches diameter, times thickness in inches = weight of grindstone in pounds.

.8862 times diam. of circle = side of a square equaling.

.7071 times diam. of circle = side of inscribed square.

1.1283 times square root of area of circle = diam. of circle.

57° 2958 in. arc having length = radius.

.017453 × radius=length of arc 1 deg.

$9.8696044 = 3.1415926^2 = \pi^2$.

$1.7724538 = \sqrt{(3.1415926)} = \sqrt{\pi}$.

0.49715=nat. log. 3.1415926.

$.31831 = \text{reciprocal of } 3.1415926 = \frac{1}{\pi}$

$.002778 = 1 \div 360 = 1\text{-}360$.

$114.59 = 360 \div 3.1415926$.

3183 × circumf. = diam. of circle.

2786° F. = melting point of iron.

2016° F. = melting point of gold.

1873° F. = melting point of silver.

2160° F. = melting point of copper.

740° F. = melting point of zinc.
620° F. = melting point of lead.
475° F. = melting point of tin.
537 lbs. per cu. ft. = weight of copper.
450 lbs. per cu. ft. = weight of cast iron.
485 lbs. per cu. ft. = weight of wrought iron.
708 lbs. per cu. ft. = weight of cast lead.
490 lbs. per cu. ft. = weight of steel.
27.684 cubic inches of water per pound at 32° F
27.759 cu. in. water per lb. at 70°
.036 lbs. per cu. in. water at 60° F.
62.355 lbs. per cu. ft. water at 62° F.
59.64 lbs per cu. ft. water at 212° F.
.54 lbs. anthracite per cu. ft.
40 to 43 cu. ft. anthracite per ton
49 cu. ft. bituminous coal per ton.
39.3685 inches = 1 meter.
3.2807 feet = 1 meter.
1.0936 yards = 1 meter.
61.02 cubic inches = 1 meter.
2.113 pints = 1 liter.
1.057 quarts = 1 liter.

BUYING OIL AND COAL.

There are many establishments which, when buying oil, coal, and such supplies, consider merely the question of first cost irrespective of their economic value. The best is not necessarily the cheapest, nor is it necessarily the dearest. The true economic value is due to the service it will perform, divided by the price.

We will take the case of coal. Some coal will evaporate ten pounds of water per pound of coal under certain conditions, and others only seven. In the one case there will be $2240 \times 10 = 22,400$ pounds of water evaporated, and in the other only $2240 \times 7 = 15,680$ pounds, under the same conditions. If the first lot sold at $5.25 per ton, and the second at only $5 the first would be the cheapest, for in the one case (including freight and labor in stoking and cost of removing ashes) we would get $22,400 \div 5.25 = 4,266.66$ pounds of steam per dollar's worth of coal, and in the other only $15,680 \div 5 = 3,136$ pounds of steam per dollar's worth of coal. Not allowing for freight and the cost of removing ashes, and not considering the capacity of the boiler with good coal as compared with its capacity with poor, the first coal would be a scheap at $6.80 per ton as the second at $5; or, to put

it the other way, the poorer coal ought to be sold at $3.85 per ton to make it as cheap as the better material at $5.25. When the other expenses are taken into consideration, the economy of buying the better coal becomes greater.

In the matter of oils: these vary in their lubricating powers, in their coolness of running, and in their durability. We will consider two oils, one at 25 cents per gallon and the other at 30, having the same lubricating power and running equally cool under free feed, but one requiring 100 gallons to keep the friction down to a minimum and the other taking only 75 gallons to effect the same object. The relative economy of these two oils is not as 30 to 25, or as 120 to 100, but as $30 \times 75 = 2{,}250$ to $25 \times 100 = 2{,}500$, or as 100 to 90; that is, the cost of the high-priced oil to effect a given desired condition is only .90 the cost of the poor oil to do the same thing; then the economy is as 100 to 90. At this rate the better grade of oil would be as cheap at

$$\frac{10 \times 30}{9} = 33\tfrac{1}{3} \text{ cents per gallon,}$$

as the cheaper at 25 cents; or the lower grade would have to be sold at

$$\frac{9 \times 25}{10} = 22\tfrac{1}{2} \text{ cents per gallon,}$$

to bring its economy down to that of the better grade; and this without counting freight, which, in many cases, should be added to the invoice price, or time in oiling, which is time lost.

NOTES ON PATTERN-MAKING.

Never work with a dull tool.

Take time to sharpen and put your tools in good order; it saves time in the end.

Above all, never use a dull or badly "set" saw. It will ruin your work, sour your temper, and make you disgusted with the whole world.

If you are varnishing or polishing a piece of work, have the room or shop warm, exclude draught and dust, and don't be in too big a hurry.

If you are polishing in the lathe, see to it that all dust and dirt are removed from the lathe-bed before you commence work.

It is better, when possible, to polish all turned work in the lathe. It always has a better appearance for it.

In making patterns for castings, if you have no experience

you had better consult some person who has had experience. Patterns are difficult things for amateurs to make if they do not understand the principles of molding and founding.

White pine or mahogany makes the best work for patterns. Lead, brass, copper and sometimes plaster of Paris are used for making patterns; especially is this so for small fine castings.

Shellac varnish is the best material for coating patterns.

Beeswax may be used for stopping up holes or to cover defects in patterns if it is coated with shellac varnish afterward. The beeswax will "take" the varnish readily, and will not cling to the "sand," like ordinary putty.

Shellac varnish may be mixed with a little lampblack to give it body and make a black pattern.

Sometimes pattern-makers use stove polish or "black lead," as it is called, to finish their patterns. It is applied nearly dry, then polished with a brush.

Wood used for patterns must be of the very best finish, straight grained, free from knots or shakes, and well seasoned.

A clean pattern gives a clean casting, and much labor may be saved by making the pattern the right size, and smooth and clean.

After patterns have been used they should be kept in a dry place, as damp will distort and otherwise injure them.

Always make a drawing of patterns before making. Much time and labor will be saved.

Where patterns part in the center they should be made to separate easily.

Put on your best workmanship when pattern making.

AN INTERESTING EXPERIMENT.

You think you stand pretty straight, don't you? Well, just back up against the wall of a room and bear against it all over; you will find there more buckles, short bends and offsets between your head and your heels than you had any idea of.

While you have your heels against the baseboard, keep them there, and reach over forward and touch your fingers to the floor, if you want a specimen of upset gravity.

A steel wire nail mill has just begun work at Hamilton, Ont. The output at present is a ton a day.

THINGS TO REMEMBER ABOUT SHAFTING.

Don't buy light hangers, and think that they will do well enough, when your own judgment tells you that they will spring.

Remember that shafting is turned one-sixteenth inch smaller than the nominal size.

Cold-rolled and hot-rolled shafting can be obtained the full size.

The sizes of shafting vary by quarter inches up to three-and-a-half inches.

The ordinary run of shafting is not manufactured longer than from 18 to 20 feet.

For line shafts, never use any that is smaller than one-and-eleven-sixteenth inches in diameter, as the smallest diameters are not strong enough to withstand the strain of the belts without springing.

The economical speed of shafting for machine shops has been found to be from 125 to 150 revolutions per minute, and for woodworking shops from 200 to 300 revolutions.

A jack-shaft is a shaft that is used to receive the entire power direct from the engine or other motor, which it delivers to the various main shafts.

Keep the shafting well lined up at all times, as this will ward off a breakdown, and avoid a waste of power.

Know that the pulleys are well balanced before they are put in position, as a pulley much out of balance is quite a sure method to throw shafting out of line.

Look to the pulleys, and see that they have been bored to the size of the shaft, for unless this is done the pulley may be out of center on the shaft and prevent smooth running.

If possible, apply the power to a line of shafting at or near the center of its length, as this will enable you to use the lightest possible weight of shafting.

Hangers with adjustable boxes will be found to be the most convenient for keeping the shafting in line.

Keep your drip-cups cleaned, and do not allow them to overflow or get loose.

Have a supply of tallow in the boxes; in case of accidental heating it will melt and prevent cutting; this rule, while good for general use, applies particularly to special cases where there is a supposed liability to heating.

Never lay tools or other things on belts that are standing still, for they may be forgotten and cause a breakdown when the machinery is started.

Don't attempt to run a shaft in a box that is too large or

too small, as you will waste time and fail to secure good results.

A loose collar held by a set screw will cause the collar to stand askew, and it will cut and wear the box against which it runs.

In erecting a line of shafting, the largest sections should be placed at the point where the power is applied. The diameter can then be gradually decreased toward the extremities remote from this point.

Don't put loose bolts in plate couplings, as this will give no end of trouble in cutting, shearing and the wearing away of the bolt holes.

Don't think that because your shafting has been well erected and you oil it regularly, that it will never need any inspection or repairs.

Don't try to economize in first cost by having long distances between hangers, for a well supported shaft will always do the best work ; short shafts are the surest to be straight and to remain so.

The length usually adopted for shafting bearings is twice to four times the diameter of the shaft, varying with the diameters of shaft, kind of bearings and the material used in them. Large shafts in the gun-metal or bronze boxes may have bearings only twice their diameter in length. Cast iron bearings up to and including three inch shafts are often made four diameters of the shaft in length, particularly for self-adjusting hangers.

If Babbit is used for the boxes, use only a good metal; do not adopt the common mixture of tin, antimony and lead.

Insist upon having good iron in your shafting, as the bearings will take a finer polish, and you will not be subject to sudden ruptures.

If the strain on a pulley is so great that the set-screws already in will not hold it, do not let them score into the shaft, but put in an extra screw, or cut a key-way and put in a key.

The width of a key-way should be one-quarter of an inch for each inch of diameter of the shaft.

The depth of a key-way is one-half its width.

WORKSHOP JOTTINGS.

To Prepare Zinc for Painting—Apply sulphuric acid and water for a quarter of an hour; then wash off clean with water and dry.

Moisture-Resisting Glue—A glue which is proof against moisture may be made by dissolving 16 ounces of glue in 3 pints of skim milk. If a stronger glue be wanted, add powdered lime.

A Good Lubricator—It may not be generally known that tallow and plumbago thoroughly mixed make the best lubricator for surfaces when one is wood or when both are wood. Oil is not so good as tallow to mix with plumbago for the lubrication of wooden surfaces, because oil penetrates and saturates the wood to a greater degree than tallow, causing it to swell more.

To Prevent Metals Rusting—The following is said to be a good application to prevent metals rusting: Melt 1 oz. of resin in a gill of linseed oil, and while hot mix with it two quarts of kerosene oil. This can be kept ready to apply at any time with a brush or rag to any tools or implements required to lay by for a time, preventing any rust, and saving much vexation when the tool is to be used again.

To Prevent Slipping of Belts—Belts conveying power are very apt to slip on pulleys, but a new pulley has been devised to prevent this. The pulley is covered with perforated sheet iron one-sixteenth of an inch thick, which is riveted to the pulley. The tension of the belt causes it to grip slightly the holes, and thus slipping is avoided, while at the same time the pulley is strengthened.

To Calculate Water in a Pipe—To calculate roughly the quantity of water in any given pipe or other cylindrical vessel, it is only necessary to remember that a pipe one yard, or three feet, long will hold about as many pounds of water as the square of its diameter in inches. Thus: If we have a pipe 20 inches in diameter and 16 feet long, we have simply to square 20 ($20^2=400$), and multiply the result by the number of times 3 feet is contained in 16 feet$=5\frac{1}{3}$ times; hence, $400 \times 5\frac{1}{3}=2,133$ pounds. By increasing the result by 2 per cent., or 1-50th, a more nearly exact figure can be obtained.

BRASS AND ITS TREATMENT.

Brass, as previously stated, is perhaps the best known and most useful alloy. It is formed by fusing together copper and zinc. Different proportions of these metals produce brasses possessing very marked distinctive properties. The portions of the different ingredients are seldom precisely alike; these depend upon the requirements of various uses for which the alloys are intended. Peculiar qualities of the constituent metals also exercise considerable influence on the results.

Brass is fabled to have been first accidentally formed at the burning of Corinth, 146 B. C., but articles of brass have been discovered in the Egyptian tombs, which prove it to have had a much greater antiquity. Brass was known to the ancients as a more valuable kind of copper. The yellow color was considered a natural quality, and was not supposed to indicate an alloy. Certain mines were much valued, as they yielded this gold-colored copper, but after a time it was found that by melting copper with a certain earth (calamine), the copper was changed in color. The nature of the change was still unsuspected.

Alloy of copper and zinc retain their malleability and ductility when the zinc is not above 33 to 40 per cent. of the alloy. When the zinc is in excess of this, crystalline character begins to prevail. An alloy of one copper to two zinc may be crumbled in a mortar when cold.

Yellow brass that files and turns well may consist of copper 4, zinc 1 to 2. A greater proportion of zinc makes it harder and less tractable; with less zinc it is more tenacious and hangs to the file like copper. Yellow brass (copper 2, zinc 1) is hardened by the addition of two to three per cent. of tin, or made more malleable by the same proportion of lead.

There would be less diversity in the results of brass castings if what was put in a crucible came out of it. The volatility of some metals, and the varied melting points of others in the same mix, greatly interfere with the uniformity in ordinary work. Zinc sublimes (burns away) at 773 to 800 degrees, while the melting heat of the copper — with which it should be intimately mixed in making brass — is nearly 1,750 degrees. Copper, zinc, tin and lead in varying proportions form alloys, always in definite quantity for a given alloy. The ease with which some of the metals are burned away at comparatively low temperatures renders it a very easy matter to make several different kinds of metal with the same mix. This very thing occurs, and the great difficulty in get-

ting bearing brasses uniform in quality causes some engineers to babbitt all bearings as the best way to insure uniformity. One lot of castings may be sōft and tough, another hard, and so on.

Zinc is added the last thing as the crucible comes out of the furnace, and the mixing of the mass is a matter of uncertainty. If the metal is too hot for the zinc a large percentage goes off in the form of a greenish cloud of vapor, and the longer the stirring goes on the more escapes. The two metals which enter into the composition of brass have an affinity for each other, but they must be brought into intimate contact before they will combine. Some brass founders use precautions to prevent volatilization of the more fusible metals, introducing them under a cover of powdered charcoal on top of the copper.

"Brass finisher" is a term many understand as applied only to those who produce highly-finished brass work; but it is not so; the brass finisher's work is not the superior class of work supposed, most of it being comprised in gas fittings, ormolu mounts, etc., but the highest class of brass finishing is a totally different process. Fittings for gas work, all finished well enough for their several purposes, and as well done as the price paid for them will allow, as well as the mountings for furniture, must obviously be produced at a low price, in order to supply the demand for cheap work of this character, most of which is simply dipping, burnishing and lacquering.

Let us follow the process of finishing the highest class of brass work. Before commencing to polish, all marks of the file must be removed, and this is done thus: Having used a superfine Lancashire file to smooth both the edges and surfaces, take a piece of moderately fine emery paper and wrap it tightly, once only, round the file. By having many folds round the file the work becomes rounded at the edges, and so made to look like second-rate things. Some use emery sticks, made of pieces of planed wood about ⅜ inch thick and ¾ inch wide, quite flat on the surfaces. They are covered with thin glue, and the emery powdered onto them, and then allowed to dry hard. Most common work is rubbed over, not to say finished, with emery cloth. This will not do for good work. The paper folded once round the file is used in a similar manner to the file, and when the file-marks disappear, and the paper is worn, a little oil is used, which makes it cut smoother. The edges and surfaces being prepared to this extent, the edges must be finished. To effect this take a piece of flat, soft wood, and apply to its

surface a little fine oil-stone powder; be sure that it is quite clean, as it is very annoying to make a deep scratch in the work just as it is finished; perhaps so deep that it will require filing out.

FACTS ABOUT A WATCH.

The watch carried by the average man is composed of ninety-eight pieces, and its manufacture embraces more than 2,000 distinct and separate operations. Some of the smaller screws are so minute that the unaided eye cannot distinguish them from steel filing or specks of dirt. Under a magnifying glass a perfect screw is revealed. The slit in the head is two one-thousandths of an inch wide. It takes 308,000 of these screws to weigh a pound, and a pound is worth $1,585. The hairspring is a strip of the finest steel, about 9½ inches long, and one-hundredth inch wide and twenty-seven ten-thousandths inch thick. It is coiled up in a spiral form and finely tempered.

The process of tempering these springs was long held as a secret by the few fortunate ones possessing it, and even now it is not generally known. Their manufacture requires great skill and care. The strip is gauged to twenty one-thousandths of an inch, but no measuring instrument has yet been devised capable of fine enough gauging to determine beforehand by the size of the strip what the strength of the finished spring will be. A twenty one-thousandth part of an inch difference in the thickness of the stop makes a difference in the running of a watch of about six minutes an hour.

The value of these springs, when finished and placed in watches, is enormous in proportion to the material from which they are made. A comparison will give a good idea. A ton of steel made up into hairsprings when in watches is worth more than 12½ times the value of the same weight in pure gold. Hairspring wire weighs 1-20 of a grain to an inch. One mile of wire weighs less than half a pound. The balance gives five vibrations every second, 300 every minute, 18,000 every hour, 432,000 every day and 157,680,000 every year. At each vibration it rotates about 1¼ times, which makes 197,100,000 revolutions every year.

In order that we may better understand the stupendous amount of labor performed by these tiny works, let us make a pertinent comparison. Take, for instance, a locomotive with six-foot driving wheels. Let its wheels be run until they have given the same number of revolutions that a watch does in one year, and they will have covered a distance equal to 28 complete circuits of the earth. All this a watch does without other attention than winding once every 24 hours.

METAL-WORKING DIES AND THEIR USES.

BY HENRY LONG.

In the following pages, which have been specially prepared for this work, will be found a condensed description of the commoner kinds of dies now in use for sheet-metal work. There being several kinds of punching presses, I will specify the variety in which each die can be used as I describe it. The commonest in use is the simple cutting-die, and I will describe it first. It can either be made by welding a steel ring of the shape desired on a wrought iron plate, and then dressing the hole out roughly to pattern while hot, or by drilling out a hole of the shape required through a piece of flat steel of proper dimensions, and then dressing it out with files, etc., to exact size. While the former plan is most expensive, it is the best in regard to wear and quality of work. Fig. 1 represents a die of this kind. The forging for this die would be made as I explained above; that is, by welding a steel ring of the shape of the pattern on an iron plate, and cutting the hole through the iron afterward. The punch for this would be made similarly, only that the ring is the shape of pattern outside, and after welding to the iron plate it is trimmed off outside. There is also a shank to be welded on the other side of plate, as nearly central as possible, and large enough to finish up easily to size required. In making this die the two faces are planed off clean, and then the pattern is laid on top face and the die is marked from it. When this is done, it is put in the shaper and planed out to the marks, care being taken to throw the work forward in the chuck to give about $\frac{1}{16}$ in. clearance to the inch, in depth.

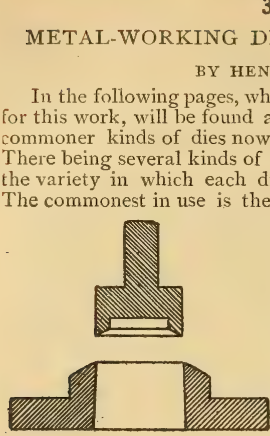


Fig. 1.

It is now filed out and champfered off on face, as shown, the face being hollowed out $\frac{1}{32}''$ on three or four sides afterward to give it a shearing edge. It is now ready for tempering. As the tempering requires great care it is very necessary to watch your heat closely, and while making it even, do not heat any higher than necessary, and plunge it carefully into cold soft water with one edge down, keeping it in there until perfectly cold. Now take it out and polish the face and inside well, and reheat very evenly as before until you observe

a dark straw color, when you can cool it off, as that is considered a good temper, and one that will stand wear without breaking. The punch is pared off on both sides and shank turned up to size, and then the die is laid on it face to face and the shape marked out. Now it is shaped off to the lines and fitted closely in the die, the inside edge of punch being afterward champfered off as shown. This die can be used in any press, and is particularly designed for light metals such as zinc, tin, etc. A flat-cutting die would be made by taking a piece cut from the bar at least 1¼″ longer and wider than your pattern, and, after planing it, lay your pattern on and mark the hole. Then drill around inside the marks and file out in same way as you do the other. The punch would be made same as last, but without champfering off the edge. This die can be used in any press, and is designed for heavy work, such as hard brass, steel, etc. Sometimes there may be some narrow or weak part in the die which is likely to break out in time, in which case it is economical to insert a plug as shown in Fig. 2. Of course these plugs can be renewed as often as necessary without disturbing the form of the die. For round holes of small size, a steel plug is fitted in a soft steel plate, and the hole drilled and reamed through it, after which the plug is tempered.

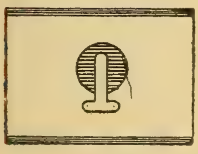


Fig. 2.

The punch is simply a socket with a set screw in which round steel of the right size is used, in this way saving any turning or fitting. Sometimes a gang of punches is used, as is shown in Fig. 3, for which a special punch is designed. In this, the shank is a separate piece, and has a dove-tailed groove planed through it. This groove should be from ⅜″ to ½″ larger in every way than the dimensions you wish to punch. It should also have $\frac{1}{32}$″ draft, or taper endwise to allow of a driving bit on the plate fitted in. This plate should be ½″ thick at least. You first drill all the holes in your die in the right position, and after reaming them out, harden and temper it. You now place this plate, which you have fitted in the shank, on the face of the die in its true position and fasten it securely there. The next thing is to run the drill you used on the

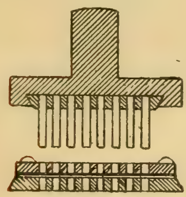


Fig. 3.

die, through the die holes, and mark their exact position on this plate. When this is done, remove the die and drill the holes through from these marks, and countersink them from behind. Now, the stripper or guide, which should be about ⅜″ thick, is fastened on in the position you wish it, and marked and drilled in the same way. The wire punches are made by riveting over a head on one end and then driving them in from the back, afterward filing off any superfluous metal which extends above the back. When you have made a gauge and placed it under the stripper, fastening securely, the die will be finished.

The punches should be filed to an even face, and then hollowed out a little to give more ease in cutting. All the dies mentioned thus far can be used in any ordinary press. We will now take up the different kinds of forming dies. There are only two kinds, half-round and square; all others are modifications of these. The depth of a half-round forming die should be two-thirds of the diameter to give the best results, and the punch should go down into the groove as shown in Fig. 4. A mandril is necessary to form the work over in the die. A square or box-forming die is simply a square hole of the right size, cut through the die, perfectly parallel, and with the upper corners rounded a little. If a smooth flat bottom is required it is usual to make the die of thinest steel, and put a plate under it as in Fig. 5, with a pad and spring, to throw it out. The punch is size of the inside of box, and a close fit. A die for forming a shape at any angle is simply a groove planed thro' the block and having a punch to fit it. Fig. 6 is a view of a common form of drawing die for deep work. They are used for making caps, cartridge cases, etc. It consists of a round disk of steel about ⅞″ deep with a hole the size of shell required bored in it.

Fig. 4.

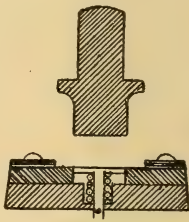


Fig. 5.

This hole is well rounded off at the corner, and counterbored from the bottom with a square, sharp shoulder for stripping the work off the punch after it has passed through the die. A cast-iron holder with set screw is generally used with these dies for convenience in changing. The punch is

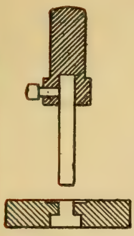


Fig. 6.

fitted into a socket in the shank and held by a set screw. It is rounded on the corners to give the metal a better chance to turn up around it. When the punch and die are set the blank is laid on the die, and the punch should be tight enough to carry it through without a wrinkle. If the shell is not long enough after this operation, make a die a little smaller and a punch the same, and after annealing the shells pass them through it. By repeating this operation you can produce shells of almost any length. Sometimes it is necessary to make a die to perform some operation on the edge of a box which has already been formed. In this case the die is made in such a way that the box can be put on it, thus placing the die on the inside. A hub is made the shape of the box, and with the die dovetailed into its upper side, a hole being bored down through the hub to allow the cuttings to fall through. This hub is fitted into a special holder as shown. The punch is made in the same way as others. These dies can be used for any operation that a flat die performs, such as cutting, forming, etc. As I have given a description of the different forms of simple dies, I will now explain some double and combination dies. A double die is two distinct dies in one plate, and it may be extended to include three or four, although the work gets complicated in this case, and the economy is doubtful.

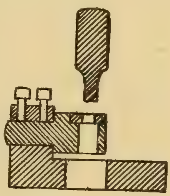


Fig. 7.

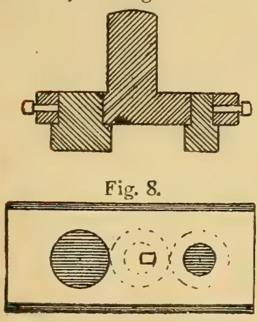


Fig. 8.

This die may be composed of two cutting dies, or one cutting and one forming die, or, in fact, any combination which may seem desirable. It is generally used for cutting dies, such as washers, etc. Fig. 8 shows the plan of one of these dies designed to make a washer. The first punch is the size of the hole in the washer and the second cuts out the washer itself. The punches are set in a long, flat socket, fastened with screws. The main point in these

dies is to get them correctly spaced so as to cut out all the stock. They can be used in a power or foot press. A combination die is one which performs two or more operations in one die. Fig. 9 is one of these, designed to make a blacking-box cover. In this die the punch comes down and cuts out the blank which is immediately gripped between the two face *a* and *b*, and held firmly enough to prevent wrinkling, but still to allow of its being drawn through and over the form which is in the center of the die. When tne press is on the return stroke, the ring *b* follows the punch up and pushes the cover off again, while the pad in the punch does the same there, thus having the cover loose on the top of the die. These dies must be operated in a power press, or one specially designed for the purpose, and they are more conveniently worked in an inclined than a horizontal press, as the work will then fall off by the force of its own gravity.

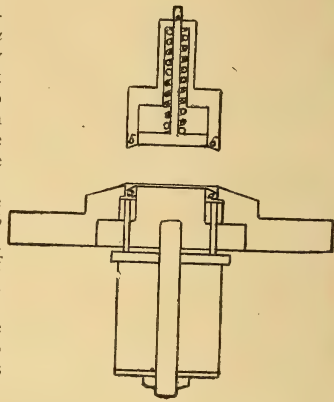


Fig. 9.

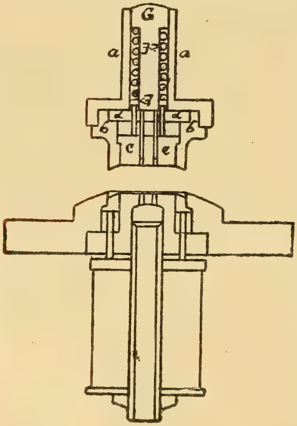


Fig. 10.

Fig. 10 is a die of the same class, but with another operation added. It is designed to make a pepper-box cover, and perforates four holes in it after it is drawn. The punch,as you will perceive, is entirely different in its construction. The die is the same, excepting that four cutting holes or dies are drilled in the top of the form

or plug, and the inside is bored out to allow the cuttings to fall through. The stub is also bored out for the same reason. In the punch *a* is the shank, bored out as shown. *b* is the cutting edge or punch proper; it is bored or chambered out for the pad *c* to work in it. *d* is a plate that screws into the top of the punch *b*, to act as a back for the pad *c* to press against, and also as a holder for the four small punches. It has three holes in it, through which short pins work to communicate the power of spring E to the pad *c*. *H* is a washer under the spring, and *G* is a plug or pin that screws in the top of shank, and extends down to the plate *d*, against which it presses, in this way hold-ing the small pin punches down to place, and guiding and regulating the spring at the same time. The operation of the die is the same as Fig. 9, only that after the tin has been drawn down its full length, the small punches cut the holes through the top, and then the pad *c* acts as a stripper for these punches at the same time as it punches the cap out of the large punch.

Fig. 11 represents a die for doing the same work, but in what is called a cam or double-action press. These dies are much simpler and cheaper to make and do equally good work with the others. The piece A is the cutting punch, and works in the die B. After cutting the blank it passes down until it presses the blank against the face shown on the inside of the die. While it is holding the blank firmly there the forming punch C passes down through the cutting punch and forces the tin down through the inside die B, in this way forming it into any shape desired. In passing up again it strips the box off against the underpart of the die, allowing it to fall into a box underneath. This covers the list as announced in the beginning of this article, and although the different kinds of dies are endless, the foregoing description will enable the reader to judge of the best way of doing work, and there is hardly any pattern which cannot be produced by one or more of these dies in combination.

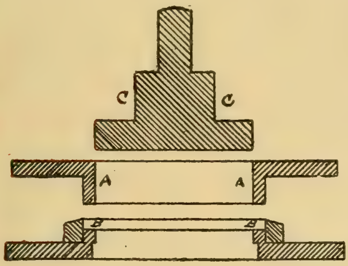


Fig. 11.

RULE TO FIND THE STRENGTH OF BOILER SHELLS AND FLUES.

The pressure for any dimension of boiler can be ascertained by the following rule, viz.:

Multiply one-sixth (1/6th) of the lowest tensile strength found stamped on any plate in the cylindrical shell by the thickness — expressed in inches, or parts of an inch — of the thinnest plate in the same cylindrical shell, and divided by the radius or half diameter — also expressed in inches — and the quotient will be the pressure allowable per square inch of surface for single riveting, to which add twenty per centum for double riveting.

Boilers built prior to February 28, 1872, shall be deemed to have a tensile strength of 50,000 pounds to the square inch, whether stamped or not.

For cylindrical boiler *flues* over 16, and less than 40 inches in diameter, the following formulas shall be used in determining the pressure allowable.

Let $D =$ diameter of flue in inches.
$1760 =$ A constant.
$T =$ thickness of flue in decimals of an inch.
$P =$ pressure of steam allowable, in pounds.

$$\frac{1760}{D} = F, \text{ a factor.}$$

$$.31 = C, \text{ a constant.}$$

Formula : $$\frac{F \times T}{C} = P.$$

EXAMPLE.

Given, a flue 20 inches in diameter, and .37 of an inch in thickness; what pressure could be allowed by the inspectors?

$$F = \frac{1760}{20.} = 88; \text{ then, } \frac{88 \times .37}{.31} = 105 + \text{ pounds as the allowable pressure.}$$

TO CALCULATE THE SPEED OF A BELT.

To find the speed a belt is traveling per minute, multiply the diameter in feet of either pulley by 3.7 times its revolutions per minute; the result is the feet travel of belt per minute if there is no slip. At the recent "Inventions Exhibition" in Liverpool, the indicated horse-power transmitted by the belting averaged, on trial, per one inch width of belt a horse power, a speed of 200 feet per minute; it would seem that a liberal factor of slip should be allowed outside of this.

SIZES AND WEIGHT OF SHEET TIN.

Mark.	No. of sheets in Box.	Dimensions. Length	Brdth.	Wt. of Box.
		Inches.	Inches.	Lbs.
IC...........	225	13¾	10	112
IIC..........	"	13¼	9¾	105
IIIC.........	"	12¾	9½	98
IX	"	13¾	10	140
IXX.........	"	"	"	161
IXXX........	"	"	"	182
IXXXX	"	"	"	203
DC..........	100	16¾	12½	105
DX..........	"	"	"	126
DXX.........	"	"	"	147
DXXX.......	"	"	"	168
DXXXX	"	"	"	189
5 DC........	200	15	11	168
5 DX........	"	"	"	189
5 DXX......	"	"	"	210
5 DXXX	"	"	"	231
5 DXXXX...	"	"	"	252
ICW.........	225	13¾	10	112

The following table, showing the number of pounds per foot in various woods, in different stages of dryness:

	Green.	Shipping dry.	Thoroughly air dried.	Kiln dried.
White ash...........	4¾	4	3½	2 4-5
Gray ash.............	4½	3¾	3	2½
Birch................	5½	4½	4	3½
Basswood	3¾	3	2½	2⅛
Cottonwood.........	3¾	3	2½	2⅛
Cherry..............	5	4½	3½	3
Chestnut............	4¼	3½	2¾	2¼
Soft elm	4	3½	3	2½
Rock elm...........	5	4¼	3¾	3¼
Hickory	5½	4¾	4	3⅓
Hard maple.........	5¼	4½	3¾	3
Bird's-eye maple	5¼	4¼	3¾	3
Curly maple.........	4¾	4	3½	2¾
White oak...........	6	5	4½	4
Red oak.............	5½	4½	3½	3
Sycamore	5	4	3	2¾
Walnut	6	5	4	3¾
Whitewood.........	4½	3½	2¾	2⅛

CALIBER AND WEIGHTS OF LEAD PIPES.

CALIBER.	WEIGHT PER FOOT. LBS.	OZ.	CALIBER.	WEIGHT PER FOOT. LBS.	OZ.
¼ in. tubing.......		6	1½ in. aqueduct...	3	
⅜ in. aqueduct....		8	ex. light.....	3	8
light........		12	light........	4	
medium.....	1		medium.....	5	
strong......	1	8	strong.......	6	
ex. strong...	2		ex. strong...	7	8
½ in. aqueduct....		10	1¾ in. light.......	3	12
ex. light.....		12	light........	4	8
light........	1		medium......	5	8
medium.....	1	4	strong......	6	8
strong......	1	12	ex. strong....	8	
ex. strong...	2	8	2 in. waste.........	3	
⅝ in. aqueduct.....		12	2 in. ex. light......	4	
ex. light.....	1	4	light........	5	
light........	1	12	medium.....	7	8
medium.....	2		strong......	8	
strong......	2	8	ex. strong...	9	
ex. strong...	3		2½ in. 3-16 thick..	8	
¾ in. aqueduct....	1		¼ thick.....	11	
ex. light.....	1	8	5-16 thick...	14	
light.........	2		⅜ thick.....	17	
medium.....	2	4	3 in. waste.......	5	
strong......	3		3-16 thick...	9	
ex. strong...	3	8	¼ thick.....	12	
⅞ in. aqueduct....	1	8	5-16 thick...	16	
ex. light.....	2		⅜ thick.....	20	
light........	2	8	3½ in. ¼ thick....	15	
1 in. aqueduct.....	1	8	5-16 thick...	18	
ex. light.....	2		⅜ thick.....	21	
light........	2	8	4 in. waste.......	5	
medium.....	3	4	¼ thick.....	16	
strong.......	4		5-16 thick...	21	
ex. strong...	4	12	⅜ thick.....	25	
1¼ in. aqueduct....	2		7-16 thick...	30	
ex. light.....	2	8	4½ in. waste.......	6	
light........	3		5 in. waste........	8	
medium.....	3	12			
strong......	4	12			
ex. strong...	6				

WEIGHT OF CIRCULAR BOILER HEADS.

Diam. in inches.	Thickness of Iron.— Inches.						
	3-16	¼	5-16	⅜	7-16	½	9-16
16	11	14	18	21	25	28	32
18	13	18	22	27	31	36	40
20	17	22	27	33	38	44	50
22	20	27	33	40	47	54	60
24	24	32	40	47	55	64	71
26	28	37	46	56	64	75	84
28	32	43	53	65	75	86	97
30	37	50	62	74	87	100	112
32	42	56	70	84	99	112	127
34	48	64	79	96	111	128	143
36	54	71	89	108	125	142	161
38	60	79	99	120	139	158	179
40	66	88	110	132	154	176	198
42	73	97	121	146	170	194	220
44	80	107	133	160	187	214	240
46	88	117	145	176	204	234	262
48	95	127	158	190	222	254	286
50	103	138	172	206	241	276	310
52	112	149	186	224	260	298	335
54	121	160	200	242	281	320	362
56	130	172	214	260	302	344	389
58	139	185	231	278	324	370	417
60	149	198	247	298	336	396	446

HOW TO CALCULATE THE CAPACITY OF TANKS.

In circular tanks, every foot of depth, five feet diameter, gives 4½ barrels of 31½ gallons each; six feet diameter, 6¾ barrels; seven feet diameter, 9 barrels; eight feet diameter, 12 barrels; nine feet diameter, 15 barrels; ten feet diameter, 18¾ barrels. In the case of square tanks, for every foot of depth 5 feet by 5 feet gives 6 barrels; 6 by 6 feet, 8½ barrels; 7 by 7 feet, 11½ barrels; 8 by 8 feet, 15½ barrels; 9 by 9 feet, 19½ barrels; 10 by 10 feet, 23¾ barrels.

NUMBER OF BOILER RIVETS IN A 100 POUND KEG.

Length.	½ Inch.	9-16 Inch.	⅝ Inch.	11-16 Inch.	¾ Inch.	⅞ Inch.
1	990	760	560	450		
1⅛	875	725	530	415		
1¼	800	690	490	389	356	228
1⅜	760	650	460	370	329	211
1½	730	625	425	357	290	180
1⅝	710	595	505	340	271	174
1¾	690	550	390	325	264	169
1⅞	665	530	375	312	257	165
2	630	510	360	297	248	156
2⅛	590	500	354	289	237	152
2¼	555	490	347	280	232	149
2½	525	475	335	260	219	141
2¾	500	440	312	242	211	133
3	460	410	290	224	203	127
3¼	430	380	267	212	190	115
3½	410	350	248	201	180	108
3¾	395	335	241	192	162	102
4		326	230	184	158	99
4¼		312	220	177	150	96
4½		298	210	171	146	94
4¾		284	200	166	138	89
5		270	190	161	135	87
5¼		256	180	156	130	84
5½		244	172	151	124	80
5¾		233	164	145	120	77
6		223	157	140	115	74
6¼		213	150	137	111	71
6		207	146	134	107	69
6		203	143	129	104	67
7		198	140	125	100	64

To Bronze Iron Castings.—After having thoroughly cleaned the castings, immerse them in a solution of sulphate of copper. The castings will then take on a coating of copper. Then wash thoroughly in water.

Copper is said to lose 18 per cent. of its tenacity upon being raised from 60° to 360°.

NUMBER OF "AMERICAN" NAILS AND CUT SPIKES IN A POUND.

Length in Inches.	Size.	Common.	Fence.	Casing.	Box.	Finishing.	Cut Spike.
1	2 F	1050					
1⅛	3 F	860					
1	2	900					
1¼	3	500		650		670	
1½	4	300		480	450	500	
1¾	5	212		350	300	370	
2	6	160	85	240	212	260	
2¼	7	135	65	190	160	210	
2½	8	95	50	135	120	155	
2¾	9	75	40				
3	10	60	35	115	100	135	16
3¼	12	48	30	100		120	
3½	16	34	25	80		100	14
4	20	24	20	65		85	12
4½	30	18		50		70	10
5	40	15		40		60	9
5½	50	12					8
6	60	10					6
7							4½
8							4

Clinch-nails weigh about the same as common.

Box-nails are made ⅛ inch shorter than common nails of same sizes.

5 lbs. of 4d or 3¾ lbs. of 3d will lay 1,000 shingles. 5¾ lbs. of 3d fine will put on 1,000 laths, four nails to the lath.

Bricks made from the refuse of slate quarries are stronger than stone; they stand 7,200 lbs. compression against 6,000 for stone, and 3,200 lbs. for common brick. The cost is from $12 to $20 per thousand.

In London 20,000 men earn their living at carpenter work' 4,000 in Paris, and 4,000 in Berlin. Hours in London are 52½ per week.

WAXING FLOORS.

Take a pound of the best beeswax, cut it up into very small pieces, and let it thoroughly dissolve in three pints of turpentine, stirring occasionally if necessary. The mixture should be only a trifle thicker than the clear turpentine. Apply it with a rag to the surface of the floor, which should be smooth and perfectly clean. This is the difficult part of the work, for, if you put on either too much or too little, a good polish will be impossible. The right amount varies, less being required for hard, close-grained wood, and more if the wood is soft and open-grained. Even professional "waxers" are sometimes obliged to experiment, and novices should always try a square foot or two first. Put on what you think will be enough, and leave the place untouched and unstepped on for twenty-four hours, or longer if needful. When it is thoroughly dry, rub it with a hard brush until it shines. If it polishes well, repeat the process over the entire floor. If it does not, remove the wax with fine sandpaper and try again, using more or less than before, as may be necessary, and continuing your experimenting until you secure the desired result. If the mixture is slow in drying, add a little of any of the common "dryers" sold by paint dealers, japan for instance, in the proportion of one part of the drier to six parts of turpentine. When the floor is a large one, you may agreeably vary the tedious work of polishing by strapping a brush to each foot and skating over it.

HOW TO MAKE AN IVORY GLOSS ON WOOD.

A most attractive ivory gloss is now imparted to wood surfaces by means of a simple process with varnish, the latter being of two kinds, namely, one a solution of colorless resin in turpentine, the other in alcohol. For the first, the purest copal is taken, while for the second sixteen parts of sandarac are dissolved in sufficient strong alcohol, to which are added three parts of camphor, and finally, when all these are dissolved, they are combined with five parts of well-shaken Venice turpentine. In order to insure the color remaining a pure white, particular care is essential that the oil be not mixed with the white paint previously put on. The best French zinc paint, mixed with turpentine, is employed, and, when dry, this is rubbed down with sandpaper, following which the varnish described is applied.

CARE OF OAK LUMBER.

Throughout the civilized world, except in extremely hot countries, one or more species of the oak is found. In this country oak forests abound in almost all the Southern and Central States. In species there are so many that even experienced lumbermen are frequently perplexed to correctly designate to which class a sample piece of wood belongs. Ordinarily in the yard trade but two kinds are known—white and red. Among shipbuilders, carriage-makers and machinists may be found live oak, a species of wood that is peculiarly adapted to purposes where immense strength is necessary. The average lumberman, when he talks about white oak or red oak, is influenced solely by the color of the wood when it becomes partially seasoned. Again and again veterans in the wood-working business have been known to select red oak for white, and *vice versa* in fact, from a dozen specimens of six different species of oak, they have been unable to correctly name a single sample.

Oak is a wood which calls for unusual and unceasing care in its manufacture. The tendency of oak, from the moment an ax is planted in the side of the tree, is to split, crack, and play all sorts of mean tricks on the owner. Such tendencies can be held in hand, and almost absolutely obviated, by following certain rules. A thick coat of waterproof paint applied to the ends of the logs is a wise expenditure; it prevents the absorption of moisture. Oak, when piled, should have the ends protected so as to prevent absorption of rain and moisture, followed by the baking process of a hot sun Alternate moisture and heat is the prime cause of checks and cracks, and when such defects begin in oak they are bound to increase and ruin otherwise perfect stock.

Oak should be stuck as fast as sawed. It is a mistake to permit it to lie in a dead pile even for a single day. It is a wood that contains a large amount of acid, which oozes to the surface as fast as the lumber is sawed, and, if the stock is allowed to remain piled solid, it is apt, even in a few hours, to cause stain on the surface. The lumber should be stuck in piles not over six feet in width. The bottom course should be raised two feet from the ground, and a space of five inches left between the pieces. It is advisable to follow this rule up to about the fifth course, when the space can be gradually diminished to two inches, and continued to the top of the pile In this way air has free circulation through the pile, and the lumber will dry readily. The pile should cant toward the back, so that rain will follow the inclination.

Board sticks not over three inches wide should be used, the front stick placed so as to project a half inch beyond the lumber. This plan permits moisture to gather in the stick, not the lumber. Other sticks should be placed not over four feet apart, and in building the pile the sticks should be exactly over one another. By this plan, warps, twists and sags are avoided.

It is advisable to pile every length by itself. This rule permits more systematic piling, and, in shipping, consignments can be made of lengths precisely as wanted. Thicknesses in piling should never be mixed. Twisted stock is certain to be the result if this advice is ignored.

The sap should be placed downward. The draft is upward, and any practical lumberman can readily observe the advantage of this advice. Every pile should be well covered with sound culls, the covering so placed as to project beyond all sides of the pile. Raise it a foot from the top course. The piles should not be nearer than twenty inches apart; twenty-four inches is better.

HOW TO SHARPEN A PLANE-IRON.

The simple art of sharpening a plane-iron is supposed to be understood by every mechanic, remarks a writer in a contemporary, but there are hundreds of men who cannot do a creditable job in this respect. The common tendency is to round off the edge of the tool until it gets so stunted that under a part of the cutting the tool strikes the work back of the cutting edge. To do the job correctly we will begin at the beginning, and grind the tool properly. First, the kind of wood to be cut must be taken into consideration. Common white pine can best be worked with a very thin tool, ground down even to an angle of 30 degrees, provided the make of the tool will allow it. Some planes will not, for the iron stands so "stunt," or nearly perpendicular, that its grinding causes a severe scraping action, which soon wears away the tool. In such cases, from 45 to 60 degrees is the proper angle for plane-irons, and this, too, is about right for hardwood planing.

Determine the angle you want on the plane-iron and then grind to that angle, taking care to grind one flat bevel, and not work up a dozen facets. If the stone be small, say 12 to 18 inches in diameter, the bevel will be slightly concave like the side of a razor, and this is a quality highly prized by many good workmen. In grinding, take care to avoid a "feather edge." If the tool already possesses the right

shape, grind carefully right up to this edge, but not grinding it entirely off. The time to stop grinding a tool is just before the old bevel is ground off.

Should the tool need any change of shape, such as the grinding out of a nick or a broken place, then put the edge of the tool against the stone and bring the tool to the desired shape before touching the bevel.

Let the iron lay perfectly flat upon the stone, with a tendency only to bear harder upon the edge of the bevel than upon the heel. Move the iron back and forth on the stone as fast as your skill will allow, taking care that the heel of the bevel is not lifted from the stone. As you become proficient in whetting an iron, the heel may be lifted from the stone about the thickness of a sheet of paper, or just enough to prevent it from touching. The reason why many carpenters cannot set an edge is because they raise their hand too much, and perhaps rock the tool, thus forming a rounding bevel; the sure mark of a poor edge-setter.

The proper way to oil-stone a tool is to continue the grinding by rubbing on the oil-stone until the bevel left by the grindstone is entirely moved and the edge keen and sharp. If this be properly done the tool need not be touched upon its face to the stone, but among a dozen good edge-setters not more than one can do it. It is a delicate operation, and can only be acquired by long practice. Nine times out of ten the average workman is obliged to turn the plane-iron over and wet the face thereof, and here is where many men fail who have done the other things well. By raising the back of the tool only a very little the edge is "dubbed off," and regrinding of the face becomes an immediate necessity. A good stone should "set" an edge on a tool which will shave off the hair on a person's wrist without cutting the skin or missing a single hair.

VALUE OF MAHOGANY.

As is known to every woodworker, mahogany has no equal for durability, brilliancy, and intrinsic value for any work which requires nicety of detail and elegance of finish. Cherry, which is a pretty wood for effect, and extremely pleasing when first finished, soon grows dull and grimy-looking. Oak, which has been so much used of late, is attractive when first finished, but experience teaches that it does not take many months to change all this, and instead of a light, fresh looking interior, one that has a dusty appearance is presented, which no amount of scraping and re-

oaking will restore to its original beauty. What applies to in this yet more applicable to ash.

Mahogany, however, seems to thrive best under the conditions which are detrimental to these other woods. At first of a light tone, it grows deeper and more beautiful in color with age, and although its first cost is more than these other woods, yet its price is much less than is popularly supposed; and the only objection urged against it has been cost. What is more valuable, however, and what makes mahogany in reality a less costly wood, is the fact that, unlike cherry, oak or ash, it is easily cleaned, because it is impervious to dust or dirt, while it does not show wear, and instead of growing duller, grows brighter and more pleasing in appearance. While first cost is more than that of cherry, oak or ash, it is nevertheless true that the judgment of many men has led them to regard mahogany as the cheaper wood when its durability and cleanly qualities are considered, and to-day it takes font rank in first-class material.

POLISHING GRANITE.

The form is given to the stone by the hands of skilled masons in much the same way as is done with other stone of softer nature. Of course, the time required is considerably greater in the case of granite as compared with other stones. If the surface is not to be polished, but only fine-axed, as it is called, that is done by the use of a hammer composed of a number of slips of steel of about a sixteenth of an inch thick, which are tightly bound together, the edges being placed on the same plane. With this tool the workman smooths the surface of the stone by a series of taps or blows given at a right angle to the surface operated upon. By this means the marks of the blows as given obliquely on the surface of the stone are obliterated, and a smooth face produced. Polishing is performed by rubbing, in the first place, with an iron tool and with sand and water. Emery is next applied, then putty with flannel. All plain surface and molding can be done by machinery, but all carvings, or surfaces broken into small portions of various elevations, are done by the hands of the patient hand-polishers.

The operation of sawing a block of granite into slabs for panels, tables or chimney-pieces is a very slow process, the rate of progress being about half an inch per day of ten hours. The machines employed are few and simple; they are technically called lathes, wagons and pendulums or rubbers. The lathes are employed for the polishing of columns, the wagons

for flat surfaces, and the pendulums for molding and such flat work as is not suitable for the wagon. In the lathe the column is placed and supported at each end by points upon which it revolves. On the upper surface of the column there are laid pieces of iron segments of the circumference of the column. The weight of these pieces of iron lying upon the column, and the constant supply of the lathe-attendant of sand and water, emery or putty, according to the state of finish to which the column has been brought, constitute the whole operation. While sand is used during the rougher state of the process these irons are bare, but when using emery and putty, the surface of the iron next to the stone is covered with thick flannel.

The wagon is a carriage running upon rails, in which the pieces of stone to be polished are fixed, having uppermost the surface to be operated upon. Above this surface there are shafts placed perpendicularly, on the lower end of which are fixed rings of iron. These rings rest upon the stone, and when the shaft revolves they rub the surface of the stone. At the same time the wagon travels backward and forward upon the rails, so as to expose the whole surface of the stone to the action of the rings. The pendulum is a frame hung upon hinges from the roof of the workshop. To this frame are attached iron rods, moving in a horizontal direction. In the line upon which these rods move, and under them, the stone is firmly placed upon the floor. Pieces of iron are then loosely attached to the rods, and allowed to rest upon the surface of the stone. When the whole is set in motion, these irons are dragged backward and forward over the surface of the stone, and so it is polished. When polishing plain surfaces, such as the needle of an obelisk, the pieces of iron are flat; but when we have to polish a molding, we make an extra pattern of its form, and the irons are cast from that pattern.

IN FAVOR OF SMALL TIMBER.

The statement that a 12x12 inch beam, built up of 2x12 planks spiked together, is stronger than a 12x12 inch solid timber, will strike a novice as exceedingly absurd. An authority on the subject says every millwright and carpenter knows that it is so, whether he ever tested it by actual experience or not. The inexperienced will fail to see why a timber will be stronger simply because the adjacent vertical longitudinal portions of the wood have been separated by a saw, and if this were the only thing about it, it would not be stronger,

but the old principle that a chain is no stronger that its weakest link comes into consideration. Most timbers have knots in them, or are sawed at an angle to the grain, so that they will split diagonally under a comparatively light load. In a built-up timber no large knots can weaken the beam except so much of it as is composed of one plank, and planks whose grain runs diagonally will be strengthened by the other pieces spiked to them.

VALUABLE ARTESIAN WELLS.

Two artesian wells recently sunk in Sonoma Valley, Cal., are considered to be worth not less than $10.000 each. One of them flows 90,000 gallons of water per day, and the other 100,000.

The cement by which many stone buildings in Paris have been renovated is likely to prove useful in preparing the foundations for machinery. The powder which forms the basis of the cement is composed of two parts of oxide of zinc, two of crushed limestone and one of pulverized grit, together with a certain proportion of ochre, as a coloring agent. The liquid with which this powder is to be mixed consists of a saturated solution of six parts of zinc in commercial muriatic acid, to which is added one part of sal-ammoniac. This solution is diluted with two-thirds of its volume of water. A mixture of one pound of the powder to two and a half pints of the liquid forms a cement which hardens quickly, and is of great strength.

Large cylinders of window-glass are now cut by encircling the cylinder with a fine wire, which is then heated to redness by an electric current, and a drop of water being allowed to fall upon the hot glass a perfectly clean cut is obtained. The old method was to draw out a fiber of white-hot semi-molten glass from the furnace by means of tongs, and to wrap it round the cylinder.

The Hudson Bay Company, which was incorporated 225 years ago, is the oldest incorporated company.

The grindstone quarries along the shores of the Bay of Fundy are developed when the tide is down. The best material is down low in the bay.

Some fine pearls were recently discovered in Tyrone (Ireland) rivers.

WOODEN BEAMS.

Safe Load. Uniformly Distributed, for Rectangular White or Yellow Pine Beams one inch thick,

allowing 1,200 lbs. per square inch fibre strain.

To obtain the safe load for any thickness, multiply the safe load given in table by the thickness of beam.

To obtain the required thickness for any load, divide by the safe load for 1 inch given in table.

Span in Feet	DEPTH OF BEAM.										
	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″
Feet	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
5	960	1310	1710	2160	2670	3230	3840	4510	5230	6000	6830
6	800	1090	1420	1800	2220	2690	3200	3760	4360	5000	5690
7	690	930	1220	1540	1900	2300	2740	3220	3730	4290	4880
8	600	820	1070	1350	1670	2020	2400	2820	3270	3750	4270
9	530	730	950	1200	1480	1790	2130	2500	2900	3330	3790
10	480	650	850	1080	1330	1610	1920	2250	2610	3000	3410
11	440	590	780	980	1210	1470	1750	2050	2380	2730	3100
12	400	540	710	900	1110	1340	1600	1880	2180	2500	2840
13	370	500	660	830	1030	1240	1480	1730	2010	2310	2630
14	340	470	610	770	950	1150	1370	1610	1870	2140	2440
15	320	440	570	720	890	1080	1280	1500	1740	2000	2280
16	300	410	530	680	830	1010	1200	1410	1630	1880	2130
17	280	380	500	640	780	950	1130	1330	1540	1760	2010
18	270	360	470	600	740	900	1070	1250	1450	1670	1900
19	250	340	450	570	700	850	1010	1190	1380	1580	1800
20	240	330	430	540	670	810	960	1130	1310	1500	1710
21	230	310	410	510	630	770	910	1070	1240	1430	1630
22	220	300	390	490	610	730	870	1020	1190	1360	1550
23	210	280	370	470	580	700	830	980	1140	1300	1480
24	200	270	360	450	560	670	800	940	1090	1250	1420
25	190	260	340	430	530	650	770	900	1050	1200	1370
26	180	250	330	420	510	620	740	870	1010	1150	1310
27	180	240	320	400	500	600	710	830	970	1110	1260
28	170	230	300	390	480	580	690	800	930	1070	1220
29	170	230	290	370	460	560	660	780	900	1030	1180

WEIGHT OF

A CUBIC FOOT OF SUBSTANCE.

Names of Substances.	Average Weight. Lbs.
Anthracite, solid, of Pennsylvania,	93
" broken, loose,	54
" " moderately shaken,	58
" heaped bushel, loose,	(80)
Ash, American white, dry,	38
Asphaltum,	87
Brass, (Copper and Zinc,) cast,	504
" rolled,	524
Brick, best pressed,	150
" common hard,	125
" soft, inferior,	100
Brickwork, pressed brick,	140
" ordinary,	112
Cement, hydraulic, ground, loose, American, Rosendale,	56
" " " " " Louisville,	50
" " " " English, Portland,	90
Cherry, dry,	42
Chestnut, dry,	41
Coal, bituminous, solid,	84
" " broken, loose,	49
" " heaped bushel, loose,	(74)
Coke, loose, of good coal,	27
" " heaped bushel,	(38)
Copper, cast,	542
" rolled,	548
Earth, common loam, dry, loose,	76
" " " " moderately rammed,	95
" as a soft flowing mud,	108
Ebony, dry,	76
Elm, dry,	35
Flint,	162
Glass, common window,	157

WEIGHT OF SUBSTANCE.

(CONTINUED.)

NAMES OF SUBSTANCES.	Average Weight Lbs
Gneiss, common,	168
Gold, cast, pure, or 24 carat,	1204
" pure, hammered,	1217
Granite,	170
Gravel, about the same as sand, which see.	
Hemlock, dry,	25
Hickory, dry,	53
Hornblende, black,	203
Ice,	58.7
Iron, cast,	450
" wrought, purest,	485
" " average,	480
Ivory,	114
Lead,	711
Lignum Vitæ, dry,	83
Lime, quick, ground, loose, or in small lumps,	53
" " " " thoroughly shaken,	75
" " " " per struck bushel,	(66)
Limestones and Marbles,	168
" " loose, in irregular fragments,	96
Mahogany, Spanish, dry,	53
" Honduras, dry,	35
Maple, dry,	49
Marbles, see Limestones.	
Masonry, of granite or limestone, well dressed,	165
" " mortar rubble,	154
" " dry " (well scabbled,)	138
" " sandstone, well dressed,	144
Mercury, at 32° Fahrenheit,	849
Mica,	183
Mortar, hardened,	103
Mud, dry, close,	80 to 110
" wet, fluid, maximum,	120
Oak, live, dry,	59

WEIGHT OF SUBSTANCES.

(CONTINUED.)

Names of Substances.	Average Weight Lbs.
Oak, white, dry,	52
" other kinds,	32 to 45
Petroleum,	55
Pine, white, dry,	25
" yellow, Northern,	34
" " Southern,	45
Platinum,	1342
Quartz, common, pure,	165
Rosin,	69
Salt, coarse, Syracuse, N. Y.	45
" Liverpool, fine, for table use,	49
Sand, of pure quartz, dry, loose,	90 to 106
" well shaken,	99 to 117
" perfectly wet,	120 to 140
Sandstones, fit for building,	151
Shales, red or black,	162
Silver,	655
Slate,	175
Snow, freshly fallen,	5 to 12
" moistened and compacted by rain,	15 to 50
Spruce, dry,	25
Steel.	490
Sulphur,	125
Sycamore, dry,	37
Tar,	62
Tin, cast,	459
Turf or Peat, dry, unpressed,	20 to 30
Walnut, black, dry,	38
Water, pure rain or distilled, at 60° Fahrenheit,	62⅓
" sea,	64
Wax, bees,	60.5
Zinc or Spelter,	437

Green timbers usually weigh from one-fifth to one-half more than dry.

ROUND CAST IRON COLUMNS.—Safe Load in Tons of 2,000 pounds; safety, 6.—These tables are based on columns made of the best iron, perfectly molded and with both ends turned.

Length.	Outside Diameter, 3 in.			Length.	Outside Diameter, 4 in.		
	½ in.	¾ in.	1 in.		½ in.	¾ in.	1 in.
3	44,070	59,890	71,190	4	61,020	85,880	106,220
4	39,394	53,535	63,636	5	56,140	79,202	98,020
5	34,579	46,992	55,859	6	51,246	72,124	89,206
6	30,231	41,083	48,835	7	46,552	65,968	82,035
7	26,268	35,698	42,433	8	41,858	58,912	72,865
8	22,812	31,001	36,851	9	37,912	53,303	65,925
9	19,844	26,967	32,056	10	33,885	47,690	58,985
10	17,339	23,564	28,010	11	30,701	42,681	53,011
11	15,147	20,694	24,630	12	27,476	38,671	47,830
12	13,402	18,213	21,650	13	25,000	34,794	43,167
13	11,785	16,123	19,223	14	22,464	31,616	39,104
14	10,469	14,335	17,097	15	20,511	28,567	35,504
15	9,453	12,847	15,271	16	18,557	26,118	32,304

	Outside Diameter, 5 in.				Outside Diameter, 6 in.		
	½ in.	¾ in.	1 in.		¾ in.	1 in.	1¼ in.
5	79,100	141,250	113,000	6	140,120	177,410	210,180
6	74,118	132,353	105,833	7	132,782	168,120	199,174
7	68,996	123,207	98,566	8	125,253	158,587	187,880
8	63,886	114,082	91,266	9	117,676	148,993	176,514
9	58,951	105,270	84,216	10	109,945	139,205	164,908
10	54,261	96,895	77,516	11	103,021	130,438	154,532
11	49,875	89,062	71,250	12	96,119	121,700	144,179
12	45,826	81,832	65,466	13	89,612	113,448	134,403
13	42,105	75,187	60,150	14	83,514	105,739	125,271
14	38,710	69,125	55,300	15	77,810	98,517	116,715
15	35,618	63,603	50,833	16	72,532	91,835	108,798
16	32,830	58,625	46,900	17	67,633	85,632	101,449
17	30,298	54,103	43,283	18	63,094	79,886	94,642
18	28,003	50,006	40,065	19	58,962	74,653	88,443
19	25,931	46,306	37,045	20	55,131	69,803	82,697
20	24,056	42,957	34,366	21	51,584	65,312	77,376
				22	48,348	61,215	72,523
				23	45,365	57,438	68,048

	Outside Diameter, 7 in.				Outside Diameter, 8 in.		
	¾ in.	1 in.	1¼ in.		¾ in.	1 in.	1¼ in.
7	166,110	212,440	255,380	8	193,230	248,600	299,450
8	158,664	202,917	243,933	9	185,671	238,876	287,737
9	151,086	193,226	232,282	10	177,942	228,932	275,759
10	143,283	183,375	220,440	11	170,110	218,856	263,622
11	135,769	173,636	208,733	12	162,279	208,780	251,485
12	128,198	163,954	197,094	18	154,359	198,638	239,268
13	120,936	154,667	185,930	14	146,700	188,738	227,343
14	113,948	145,730	175,186	15	139,655	179,674	216,425
15	107,824	137,258	165,002	16	132,552	170,535	205,417
16	101,062	129,250	155,375	17	125,787	161,832	194,934
17	95,123	121,654	146,244	18	119,323	153,516	184,917
18	89,567	114,548	137,701	19	113,150	145,574	175,350
19	84,275	107,780	129,565	20	107,302	138,050	166,487
20	78,380	101,520	122,040	21	101,796	130,966	157,754
21	74,798	95,660	114,995	22	96,580	124,256	149,672
22	70,589	90,277	108,525	23	91,656	117,920	142,040
23	66,635	85,220	102,458	24	87,009	111,942	134,839
24	62,930	80,482	96,750	25	82,695	106,392	128,154

ROUND CAST IRON COLUMNS — (Continued).

Length.	Outside Diameter, 15 in.			Length.	Outside Diameter, 16 in.		
	1 in.	1½ in.	2 in.		1½ in.	2 in.	2½ in.
15	496,974	718,793	922,884	16	772,129	993,648	1,198,139
16	486,727	708,972	903,958	17	757,143	974,785	1,175,918
17	476,259	688,833	884,513	18	741,995	955,158	1,151,380
18	465,654	673,566	864,910	19	726,521	935,897	1,127,523
19	454,973	658,045	844,980	20	711,042	915,312	1,103,348
20	444,242	642,525	825,050	21	695,394	895,149	1,079,067
21	433,467	626,940	805,038	22	679,610	874,750	1,054,574
22	422,736	611,419	785,108	23	664,031	854,795	1,030,400
23	412,005	595,898	766,178	24	648,452	834,740	1,006,225
24	401,405	580,568	745,493	25	632,941	814,773	982,156
25	300,938	565,429	726,054	26	617,567	794,982	958,299
26	380,559	550,417	706,777	27	602,329	775,367	934,657
27	370,400	535,733	687,909	28	587,296	756,016	911,328
28	360,240	521,220	669,286	29	572,537	737,017	888,365
29	350,565	507,035	651,071	30	557,983	718,281	865,841
30	340,933	493,105	633,183	31	543,702	699,918	843,681
31	330,921	479,492	615,704	32	529,694	681,866	822,345
32	322,329	466,198	598,633	33	515,960	664,186	800,683

	Outside Diameter, 17 in.				Outside Diameter, 17 in.		
	1½ in.	2 in.	2½ in.		1½ in.	2 in.	2½ in.
17	825,352	1,065,025	1,286,844	26	686,503	885,856	1,070,358
18	809,752	1,045,798	1,263,612	27	671,018	865,875	1,046,216
19	795,333	1,026,198	1,240,089	28	655,753	846,176	1,022,415
20	779,994	1,006,495	1,216,125	29	640,634	825,667	998,841
21	764,510	986,515	1,191,982	30	625,661	807,345	975,496
22	748,952	966,439	1,167,726	31	610,907	788,807	952,492
23	733,832	946,270	1,143,355	32	596,455	769,645	929,944
24	717,618	226,006	1,118,871	33	582,132	744,267	907,737
25	702,060	905,981	1,094,615	34	566,206	730,626	882,798

NEW STEEL RAILS USED AS LINTELS OR GIRDERS.

Safe load in tons of 2000 lbs.

Length	2	3	4	5	6	7	8	9
52 lb. rail, per yard	10.75	7.00	5.50	4.25	3.50	3.	2.75	2.50
60 lb. rail, per yard	12.	8.00	5.65	4.75	4.00	3.50	3.	2.70
Deflection in inches	0.045	0.050	0.075	0.090	0.125	0.170	0.225	0.300
Length	10	11	12	13	14	15	16	
52 lb rail, per yard	2.	1.90	1.80	1.70	1.50	1.40	1.30	
60 lb rail, per yard	2.40	2.20	2	1.80	1.70	1.60	1.50	
Deflection in inches	0.375	0.450	0.535	0.630	0.730	0.830	0.930	

AREAS OF CIRCLES.

Advancing by Eighths.

Diam.	AREAS. .0	.1/8	.1/4	.3/8	.1/2	.5/8	.3/4	.7/8
0	.0	.0122	.0490	.1104	.1963	.3068	.4417	.6013
1	.7854	.9940	1.227	1.484	1.767	2.078	2.405	2.761
2	3.1416	3.546	3.976	4.430	4.908	5.411	5.939	6.491
3	7.068	7.669	8.295	8.946	9.621	10.32	11.04	11.79
4	12.56	13.36	14.18	15.03	15.90	16.80	17.72	18.66
5	19.63	20.62	21.64	22.69	23.75	24.85	25.96	27.10
6	28.27	29.46	30.67	31.91	33.18	34.47	35.78	37.12
7	38.48	39.87	41.28	42.71	44.17	45.66	47.17	48.70
8	50.26	51.84	53.45	55.08	56.74	58.42	60.13	61.86
9	63.61	65.39	67.20	69.02	70.88	72.75	74.66	76.58
10	78.54	80.51	82.51	84.54	86.59	88.66	90.76	92.88
11	95.03	97.20	99.40	101.6	103.8	106.1	108.4	110.7
12	113.0	115.4	117.8	120.2	122.7	125.1	127.6	130.1
13	132.7	135.2	137.8	140.5	143.1	145.8	148.4	151.2
14	153.9	156.6	159.4	162.2	165.1	167.9	170.8	173.7
15	176.7	179.6	182.6	185.6	188.6	191.7	194.8	197.9
16	201.0	204.2	207.3	210.5	213.8	217.0	220.3	223.6
17	226.9	230.3	233.7	237.1	240.5	243.9	247.4	250.9
18	254.4	258.0	261.5	265.1	268.8	272.4	276.1	279.8
19	283.5	287.2	291.0	294.8	298.6	302.4	306.3	310.2
20	314.1	318.1	322.0	326.0	330.0	334.1	338.1	342.2
21	346.3	350.4	354.6	358.8	363.0	367.2	371.5	375.8
22	380.1	384.4	388.8	393.2	397.6	402.0	406.4	410.9
23	415.4	420.0	424.5	429.1	433.7	438.3	443.0	447.6
24	452.3	457.1	461.8	466.6	471.4	476.2	481.1	485.9
25	490.8	495.7	500.7	505.7	510.7	515.7	520.7	525.8
26	530.9	536.0	541.1	546.3	551.5	556.7	562.0	567.2
27	572.5	577.8	583.2	588.5	593.9	599.3	604.8	610.2
28	615.7	621.2	626.7	632.3	637.9	643.5	649.1	654.8
29	660.5	666.2	671.9	677.7	683.4	689.2	695.1	700.9
30	706.8	712.7	718.6	724.6	730.6	736.6	742.6	748.6
31	754.8	760.9	767.0	773.1	779.3	785.5	791.7	798.0
32	804.3	810.6	816.9	823.2	829.6	836.0	842.4	848.8
33	855.3	861.8	868.3	874.9	881.4	888.0	894.6	901.3
34	907.9	914.7	921.3	928.1	934.8	941.6	948.4	955.3
35	962.1	969.0	975.9	982.8	989.8	996.8	1003.8	1010.8
36	1017.9	1025.0	1032.1	1039.2	1046.3	1053.5	1060.7	1068.0
37	1075.2	1082.5	1089.8	1097.1	1104.5	1111.8	1119.2	1126.7
38	1134.1	1141.6	1149.1	1156.6	1164.2	1171.7	1179.3	1186.9
39	1194.6	1202.3	1210.0	1217.7	1225.4	1233.2	1241.0	1248.8
40	1256.6	1264.5	1272.4	1280.3	1288.2	1296.2	1304.2	1312.2
41	1320.3	1328.3	1336.4	1344.5	1352.7	1360.8	1369.0	1377.2
42	1385.4	1393.7	1402.0	1410.3	1418.6	1427.0	1435.4	1443.8
43	1452.2	1460.7	1469.1	1477.6	1486.2	1494.7	1503.3	1511.9
44	1520.5	1529.2	1537.9	1546.6	1555.3	1564.0	1572.8	1581.6
45	1590.4	1599.3	1608.2	1617.0	1626.0	1634.9	1643.9	1652.9

CIRCUMFERENCES OF CIRCLES.

Advancing by Eighths.

Diam.	CIRCUMFERENCES. /0	.⅛	.¼	.⅜	.½	.⅝	.¾	.⅞
0	.0	.3927	.7854	1.178	1.570	1.963	2.356	2.748
1	3.141	3.534	3.927	4.319	4.712	5.105	5.497	5.890
2	6.283	6.675	7.068	7.461	7.854	8.246	8.639	9.032
3	9.424	9.817	10.21	10.60	10.99	11.38	11.78	12.17
4	12.56	12.95	13.35	13.74	14.13	14.52	14.92	15.31
5	15.70	16.10	16.49	16.88	17.27	17.67	18.06	18.45
6	18.84	19.24	19.63	20.02	20.42	20.81	21.20	21.59
7	21.99	22.38	22.77	23.16	23.56	23.95	24.34	24.74
8	25.13	25.52	25.91	26.31	26.70	27.09	27.48	27.88
9	28.27	28.66	29.05	29.45	29.84	30.23	30.63	31.02
10	31.41	31.80	32.20	32.59	32.98	33.37	33.77	34.16
11	34.55	34.95	35.34	35.73	36.12	36.52	36.91	37.30
12	37.69	38.09	38.48	38.87	39.27	39.66	40.05	40.44
13	40.84	41.23	41.62	42.01	42.41	42.80	43.19	43.58
14	43.98	44.37	44.76	45.16	45.55	45.94	46.33	46.73
15	47.12	47.51	47.90	48.30	48.69	49.08	49.48	49.87
16	50.26	50.65	51.05	51.44	51.83	52.22	52.62	53.01
17	53.40	53.79	54.19	54.58	54.97	55.37	55.76	56.15
18	56.54	56.94	57.33	57.72	58.11	58.51	58.90	59.29
19	59.69	60.08	60.47	60.86	61.26	61.65	62.04	62.43
20	62.83	63.22	63.61	64.01	64.40	64.79	65.18	65.58
21	65.97	66.36	66.75	67.15	67.54	67.93	68.32	68.72
22	69.11	69.50	69.90	70.29	70.68	71.07	71.47	71.86
23	72.25	72.64	73.04	73.43	73.82	74.22	74.61	75.00
24	75.39	75.79	76.18	76.57	76.96	77.36	77.75	78.14
25	78.54	78.93	79.32	79.71	80.10	80.50	80.89	81.28
26	81.68	82.07	82.46	82.85	83.25	83.64	84.03	84.43
27	84.82	85.21	85.60	86.00	86.39	86.78	87.17	87.57
28	87.96	88.35	88.75	89.14	89.53	89.92	90.32	90.71
29	91.10	91.49	91.89	92.28	92.67	93.06	93.46	93.85
30	94.24	94.64	95.03	95.42	95.81	96.21	96.60	96.99
31	97.39	97.78	98.17	98.57	98.96	99.35	99.75	100.14
32	100.53	100.92	101.32	101.71	102.10	102.49	102.89	103.29
33	103.67	104.07	104.46	104.85	105.24	105.64	106.03	106.42
34	106.81	107.21	107.60	107.99	108.39	108.78	109.17	109.56
35	109.96	110.35	110.74	111.13	111.53	111.92	112.31	112.71
36	113.10	113.49	113.88	114.28	114.67	115.06	115.45	115.85
37	116.24	116.63	117.02	117.42	117.81	118.20	118.61	118.99
38	119.38	119.77	120.17	120.56	120.95	121.34	121.74	122.13
39	122.52	122.92	123.31	123.70	124.09	124.49	124.88	125.27
40	125.66	126.06	126.45	126.84	127.24	127.63	128.02	128.41
41	128.81	129.20	127.59	129.98	130.38	130.77	131.16	[illegible].55
42	131.95	132.34	132.73	133.13	133.52	133.91	134.30	134.70
43	135.09	135.48	135.87	136.27	136.66	137.05	137.45	137.84
44	138.23	138.62	139.02	139.41	139.80	140.19	140.59	140.98
45	141.37	141.76	142.16	142.55	142.94	143.34	143.73	144.12

WEIGHT OF CAST IRON COLUMN PER LINEAL FOOT OF PLAIN SHAFT.

Diam.	THICKNESS OF METAL.											
	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.	1½ in.	1¾ in.	2 in.
2	4.3	6.0	7.4	8.4	9.2	9.7	9.8	.....	.....	.....	.....	.....
2½	5.5	7.8	9.8	11.5	12.9	14.0	14.7	.....	.....	.....	.....	.....
3	6.8	9.7	12.3	14.6	16.6	18.3	19.6	.....	.....	.....	.....	.....
3½	8.0	11.5	14.7	17.6	20.3	22.6	24.6	.....	.....	.....	.....	.....
4	9.2	13.3	17.2	20.7	23.9	26.8	29.5	.....	.....	.....	.....	.....
4½	10.4	15.2	19.6	23.8	27.6	31.1	34.4	37.3	39.9	.....	.....	.....
5	11.7	17.0	22.1	26.9	31.3	35.4	39.3	42.8	46.0	.....	.....	.....
5½	12.9	18.9	24.5	29.9	35.0	39.7	44.2	48.3	52.2	.....	.....	.....
6	14.1	20.7	27.8	33.0	38.7	44.0	49.1	53.9	58.3	.....	.....	.....
6½	15.3	22.6	29.5	36.1	42.3	48.3	54.0	59.4	64.4	.....	.....	.....
7	16.6	24.4	31.9	39.1	46.0	52.6	58.9	64.9	70.6	81.0	.....	.....
7½	17.8	26.2	34.4	42.2	49.7	56.9	63.8	70.4	76.7	88.4	.....	.....
8	19.0	28.1	36.8	45.3	53.4	61.2	68.7	75.9	82.8	95.7	.....	.....
8½	20.2	29.9	39.3	48.3	57.1	65.5	73.6	81.5	89.0	103.1	.....	.....
9	21.5	31.8	41.7	51.4	60.8	69.8	78.5	87.0	95.1	110.5	.....	.....
9½	22.7	33.6	44.2	54.5	64.4	74.1	83.5	92.5	101.2	117.8	133.2	.....
10	23.9	35.4	46.6	57.5	68.1	78.4	88.4	98.0	107.4	125.2	141.7	157.1
10½	25.2	37.3	49.1	60.6	71.8	82.7	93.3	103.5	113.5	132.5	150.3	166.9
11	26.4	39.1	51.6	63.7	75.5	87.0	98.2	109.1	119.7	139.9	158.9	176.7
11½	27.6	41.0	54.8	66.7	79.2	91.3	103.1	114.6	125.8	147.3	167.5	186.5
12	28.8	42.8	56.5	69.8	82.8	95.6	108.0	120.1	131.9	154.6	176.1	196.3
12½	.....	44.6	58.9	72.9	86.5	99.9	112.9	125.6	138.1	162.0	184.7	206.2
13	.....	46.5	61.4	75.9	90.2	104.2	117.8	131.2	144.2	169.4	193.3	216.0
13½	.....	.....	63.8	79.0	93.9	108.5	122.7	136.7	150.3	176.7	201.9	225.8
14	.....	.....	66.3	82.1	97.6	112.8	127.6	142.2	156.5	184.1	210.5	235.6
14½	.....	.....	68.7	85.2	101.2	117.0	132.5	147.7	162.6	191.4	219.1	245.4
15	.....	.....	71.2	88.2	104.9	121.3	137.5	153.2	168.7	198.8	227.6	255.2
16	.....	.....	76.1	94.3	112.3	129.9	147.3	164.3	181.0	213.5	244.8	274.9
17	.....	.....	81.0	100.5	119.7	138.5	157.1	175.3	193.3	228.3	262.0	294.5
18	.....	.....	85.9	106.6	127.0	147.1	166.9	186.4	205.6	243.0	279.2	314.1
19	.....	.....	90.8	112.8	134.4	155.7	176.7	197.4	217.8	257.7	296.4	333.8
20	.....	.....	95.7	118.9	141.7	164.3	186.5	208.5	230.1	274.4	313.5	353.4

INCREASE IN WEIGHT FOR ½ IN INCREASE IN DIAMETER.

¼ in.	⅝ in.	½ in.	⅜ in.	¾ in.	⅞ in.	1 in.	1⅛ in.	1¼ in.	1½ in.	1¾ in.	2 in.
1.2	1.8	2.5	3.1	3.7	4.3	4.9	5.5	6.1	7.4	8.6	9.8

Weight of Square or Rectangular Cast Iron Column Shafts Per Lineal Foot.

EXAMPLE: Column $6'' \times 10'' \times 1' + 10' 0'$. $6'' \times 10'' = 16'' \times 2 = 32$. Following out line on which 32 is found in left hand column to column headed 1″, we find the weight per foot to be 87.5 pounds, which, multiplied by $10'\ 1'' = 875$ pounds.

A B 2a + 2b	METAL.								
	⅝″	¾″	⅞″	1″	1⅛″	1¼″	1½″	1¾″	2″
12	18.6	21.1	23.3	25.0	26.4	27.3	28.1	....	....
14	22.5	25.8	28.7	31.3	33.4	35.1	37.5	....	....
16	26.4	30.5	34.2	37.5	40.4	43.0	46.9	49.2	50.0
18	30.3	35.2	39.7	43.8	47.4	50.8	56.3	60.2	62.5
20	34.2	39.8	45.1	50.0	54.5	58.6	65.6	71.1	75.0
22	38.1	44.5	50.6	56.3	61.5	66.4	75.0	82.0	87.5
24	42.0	49.2	56.1	62.5	68.5	74.2	84.4	93.0	100.0
26	45.9	53.9	61.5	68.8	75.6	82.0	93.8	103.9	112.5
28	49.8	58.6	67.0	75.0	82.6	89.8	103.7	114.8	125.0
30	53.7	63.3	72.5	81.3	89.6	97.7	112.5	125.8	137.5
32	57.6	68.0	77.9	87.5	96.7	105.5	121.9	137.7	150.0
34	61.5	72.7	83.4	93.8	103.7	113.3	131.3	147.7	162.5
36	65.4	77.3	88.9	100.0	110.7	121.1	140.6	158.6	175.0
38	69.3	82.0	94.3	106.3	117.8	128.9	150.0	169.5	187.5
40	73.2	86.7	99.8	112.5	124.8	136.7	159.4	180.5	200.0
42	77.1	91.4	105.3	118.8	131.8	144.5	168.8	191.4	212.5
44	81.0	96.1	110.8	125.0	138.8	152.3	178.1	202.3	225.0
46	84.9	100.8	116.2	131.3	145.9	160.2	187.5	213.3	237.5
48	88.8	105.5	121.7	137.5	152.9	168.0	196.9	224.2	250.0
50	92.8	110.2	127.2	143.8	159.9	175.8	206.3	235.2	262.5
52	96.7	114.8	132.6	150.0	167.0	183.6	215.6	246.3	275.0
54	100.6	119.5	138.1	156.3	174.0	141.4	225.0	257.0	287.6
56	104.5	124.2	143.6	162.5	181.0	199.2	234.4	268.0	300.0
58	108.4	128.9	149.0	168.8	188.1	207.0	243.8	278.9	312.5
60	112.3	133.6	154.5	175.0	195.1	214.9	253.2	289.8	325.0
62	116.2	138.3	160.0	181.3	202.1	222.7	262.5	300.8	337.5
64	120.1	143.0	165.4	187.5	209.2	230.5	271.9	311.7	350.0
66	124.0	147.7	170.9	193.8	216.2	238.3	281.3	322.7	362.5
68	127.9	152.3	176.4	200.0	223.2	246.1	290.6	336.6	375.0
70	131.8	157.0	181.8	206.3	230.3	253.9	300.0	344.5	387.5
72	135.7	161.7	187.7	212.5	237.3	261.7	309.4	355.5	400.0
74	139.5	166.4	192.8	218.8	244.3	269.5	318.8	366.4	412.5
76	143.5	171.1	198.3	225.0	251.3	277.3	328.1	377.3	425.0
78	147.4	175.8	203.7	231.3	258.4	285.2	337.5	383.3	437.5
80	151.3	180.5	209.2	237.5	265.4	293.0	340.9	399.2	450.0

CUBIC MEASURE.

Inches.		Feet.		Yard.		Cubic Metres
1.	=	0005788	=	.000002144	=	.000016386
1728.		1.		.03704		.028315
46656.		27.		1.		764513

A CUBIC FOOT IS EQUAL TO

1728	cubic inches	29.92208	U. S. liquid quarts.
.037037	cubic yard	25.71405	U S dry quarts
803564	U S struck bushel of 2150 42 cub. in	59 84416	U S liquid pints
		51.42809	U S. dry pints.
3 21426	U S. pecks	239.37662	U. S. gills.
7.48052	U. S liquid gallons of 231 cub in.	.26667	flour barrel of 3 struck bushels
6.42851	U. S dry gallons of 268.8025 cub in	.23748	U S. liquid barrel of 31½ gallons.

A cubic inch of water at 62° Fahr weighs 252.458 grains.
A cubic foot of water at 62° Fahr weighs 1002.7 ounces.
A cubic yard of water at 62° Fahr. weighs 1692. pounds

FRENCH CUBIC OR SOLID MEASURE.

		Pint	Quart.	Bush.	Cubic Inch.	Cu Ft
Centilitre	Dry	.0181	......	......	61016	
	Liquid	.0211	......	......		
Decilitre	Dry	.1816	0908	......	6.1016	
	Liquid	.2113	1056	......		
Litre	Dry	1.816	.908	......	61.016	.0353
	Liquid	2.113	1.056	....		
Decalitre	Dry	....	9 08	2837	610.16	.3531
	Liquid	21 13	10 56	......		
Hectolitre	Dry	....	90.8	2.837	6101 6	3.531
	Liquid	211 3	105 6	...		
Kilolitre or Cubic Metre	Dry	...	.....	28.37	61016.	35.31
	Liquid	..	1056.5	......		
Myriolitre	Dry	...	...	283.7		353.1
	Liquid		10565.	...		

AVOIRDUPOIS WEIGHT.

The standard avoirdupois pound is the weight of 27.7015 cubic inches of distilled water, weighed in the air, at 39.83 degrees Fahr., barometer at thirty inches.

Ounces.		Pounds.		Quarters.		Cwts.		Ton.
1.	=	.0625	=	.00223	=	.000558	=	.000028
16.		1.		.0357		.00893		.000447
448.		28.		1.		.25		.0125
1792.		112.		4.		1.		.05
35840.		2240.		80.		20.		1.

A drachm = 27.343 grains.
A stone = 14 pounds.
A quintal = 100 kilogrammes.

7000 grains = 1 avoir. pound = 1.21528 troy pounds.
5760 grains = 1 troy pound = .82285 avoir. pound.

Kilos p. sq. centim. × 14.22 = Pounds p. sq. inch.
Pounds p. sq. inch × .0703 = Kilos p. sq. centim.

FRENCH WEIGHTS.

EQUIVALENT TO AVOIRDUPOIS.

	Grains.	Ounces.	Pounds.
Milligramme	.015433		
Centigramme	.154331	.000352	.000022
Decigramme	1.54331	.003527	.000220
Gramme	15.4331	.035275	.002204
Decagramme	154.331	352758	.022047
Hectogramme	1543.31	3.52758	.220473
Kilogramme	15433.1	35.2758	2.20473
Myriogramme		352.758	22.0473
Quintal		3527 58	220.473
Millier or Tonne		35275.8	2204.73

SQUARE MEASURE.

Inches		Feet.	Yard	Perches.	Acre.
1.	=	.00694 =	000772 =	.0000255 =	.000000159
144.	1.		.111	.00367	.000023
1296.	9.		1.	.0331	.0002066
39204.	272¼.		30¼.	1.	.00625
6272640.	43560.		4840.	160.	1

100 square feet = 1 square.
10 square chains = 1 acre.
1 chain wide = 8 acres per mile.
1 hectare = 2.471143 acres.

1 square mile $\begin{cases} = 27,878,400 \text{ square feet.} \\ = 3,097,600 \text{ square yards.} \\ = 640 \text{ acres.} \end{cases}$

Acres × 0015625 = square mile
Square yard × 000000323 = square miles
Acres × 4840 = square yards
Square yards × 0002066 = acres.

A section of land is 1 mile square, and contains 640 acres.
A square acre is 208 71 ft at each side; or, 220 × 198 ft.
A square ½ acre is 147 58 ft at each side, or, 110 × 198 ft.
A square ¼ acre is 104.355 ft. at each side, or, 55 × 198 ft.
A circular acre is 235 504 ft in diameter.
A circular ½ acre is 166 527 ft. in diameter
A circular ¼ acre is 117.752 ft in diameter

FRENCH SQUARE MEASURE.

Square	Square Inches	Square Feet	Square Yards
Millimetre.	00154	0000107	000001
Centimetre	15498	.0010763	.000119
Decimetre	15 498	1076305	011958
Met or Cen	1549 8	10 76305	1 19589
Decametre	154988	1076 305	119.589
Hectare ..	....	107630 58	11958 95
Kilometre	.38607 □ mls	10763058	1195895.
Myriamet..	38.607	....	....

SURVEYING MEASURE.

(LINEAL.)

Inches.		Feet.		Yards.		Chains.		Mile.
1.	=	.0833	=	.0278	=	.00126	=	.0000158
12.		1.		.333		.01515		.000189
36.		3.		1.		.04545		.000568
792.		66.		22.		1.		.0125
63360.		5280.		1760.		80.		1.

One knot or geographical mile = 6086.07 feet = 1855.11 metres = 1.1526 statute mile.

One admiralty knot = 1.1515 statute miles = 6080 feet.

LONG MEASURE.

Inches.		Feet.		Yards.		Poles.		Furl.		Mile.
1.	=	.083	=	.02778	=	.005	=	.000126	=	.0000158
12.		1.		.333		.0606		.00151		.0001894
36.		3.		1.		.182		.00454		.000568
198.		16½.		5½.		1.		.025		.003125
7920.		660.		220.		40.		1.		.125
63360.		5280.		1760.		320.		8.		1.

A palm = 3 inches. A hand = 4 inches.
A span = 9 inches. A cable's length = 120 fathoms.

FRENCH LONG MEASURE.

	Inches.	Feet.	Yards.	Miles.
Millimetre	.03937	.0033	....	....
Centimetre	.39368	.0328	....	....
Decimetre	3.9368	.3280	.10936	....
Metre	39.368	3.2807	1.09357	....
Decametre	393.68	32.807	10.9357	....
Hectometre	....	328 07	109 357	062134
Kilometre	....	3280.7	1093 57	621346
Myriametre	....	32807.	10935.7	6.213466

STRENGTH OF MATERIALS.

ULTIMATE RESISTANCE TO TENSION

IN LBS. PER SQUARE INCH.

METALS.

	Average.
Brass, cast,	18000
" wire,	49000
Bronze or gun metal,	36000
Copper, cast,	19000
" sheet,	30000
" bolts,	36000
" wire,	60000
Iron, cast, 13400 to 29000,	16500
" wrought, round or square bars of 1 to 2 inch diameter, double refined,	50000 to 54000
" wrought, specimens ½ inch square, cut from large bars of double refined iron,	50000 to 53000
" wrought, double refined, in large bars of about 7 square inches section,	46000 to 47000
" wrought, plates, angles and other shapes,	48000 to 51000
" " plates over 36″ wide,	46000 to 50000

Wrought iron, suitable for the tension members of bridges, should be double refined, and show a permanent elongation of 20 per cent in 5″, when broken in small specimens, and a reduction of area of 25 per cent at point of fracture

The modulus of elasticity of Union Iron Mills' double refined bar iron is 25000000 to 26000000, from tests made on finished eyebars

Iron, wire,	70000 to 100000
" wire-ropes,	90000
Lead, sheet,	3300
Steel,	65000 to 120000
Tin, cast,	4600
Zinc,	7000 to 8000

STRENGTH OF MATERIALS.

(CONTINUED.)

TIMBER, SEASONED, AND OTHER ORGANIC FIBER.

	Average.
Ash, English,	17000
" American,	11000 to 14000
Beech, "	15000 to 18000
Box,	20000
Cedar of Lebanon,	11400
" American, red,	10300
Fir or Spruce,	10000 to 13600
Hempen Ropes,	12000 to 16000
Hickory, American,	12800 to 18000
Mahogany,	8000 to 21800
Oak, American, white,	18000
" European,	10000 to 19800
Pine, American, white, red and pitch, Memel, Riga,	10000
" " long leaf yellow,	12600 to 19200
Poplar,	7000
Silk fiber,	52000
Walnut, black,	16000

STONE, NATURAL AND ARTIFICIAL.

Brick and Cement,	280 to 300
Glass,	9400
Slate,	9600 to 12800
Mortar, ordinary,	50

ULTIMATE RESISTANCE TO COMPRESSION.

METALS.

Brass, cast,	10300
Iron, "	82000 to 145000
" wrought,	36000 to 40000

STRENGTH OF MATERIALS.

(CONTINUED.)

TIMBER, SEASONED, COMPRESSED IN THE DIRECTION OF THE GRAIN

	Average.
Ash, American,	4400 to 5800
Beech,	5800 to 6900
Box,	10300
Cedar of Lebanon,	5900
" American, red,	6000
Deal, red,	6500
Fir or Spruce,	5100 to 6800
Oak, American, white,	7200 to 9100
" British,	10000
" Dantzig,	7700
Pine, American, white,	5000 to 5600
" " long leaf, yellow	8000
Spruce or Fir,	5800 to 6900
Walnut, black,	7500

STONE, NATURAL OR ARTIFICIAL.

Brick, weak,	550 to 800
" strong,	1100
" fire,	1700
Brickwork, ordinary, in cement,	300 to 450
" best,	1000
Chalk,	330
Granite,	5500 to 11000
Limestone,	4000 to 11000
Sandstone, ordinary,	4000

ULTIMATE RESISTANCE TO SHEARING

METALS.

Iron, cast,	27700
" wrought, along the fiber,	45000

TIMBER, ALONG THE GRAIN.

White Pine, Spruce, Hemlock,	500 to 800
Yellow Pine, long leaf,	630 to 960
Oak, European,	2300
Ash, American,	2000

Table of Safety Load of Cast Iron Columns—Factor of Safety 10.

This factor of safety of 10 has been adopted to allow for imperfections in casting; such as air-holes, unequal thickness of metal, etc., devietion of pressure from axis of columns, and the effect of latenal forces accidentally applied. Where these risks do not occur, a factor of 6 may be taken for safe load. Ends of columns should always be turned true.

Outside Diameter in inches.	Thickness of Metal.	LENGTH OF COLUMNS IN FEET. Both Ends Turned. 6	8	10	12	14	16	18	20	22	24	26	28	30	Sectional area in inches.	Weight in lbs. of Columns per foot of length.
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.		
4	½	11.	8.1	6.1	4.7	3.6	3.4	2.8	2.0	.....	.....	.....	.....	.....	5.492	17.14
	¾	15.2	11.3	8.5	6.5	4.8	3.8	3.3	2.8	.....	.....	.....	.....	.....	7.66	23.90
5	½	10.8	13.3	10.4	8.3	6.7	5.4	5	4	.....	.....	.....	.....	.....	7.07	22.06
	¾	24	19	15	12	9	7.7	6.5	5.7	.....	.....	.....	.....	.....	10.01	31.23
6	½	23	19	15.5	12.7	9.5	8.7	7.3	6.2	.....	.....	.....	.....	.....	8.64	26.95
	¾	33	27	22	18	15	13	11	9	.....	.....	.....	.....	.....	12.37	38.59
	⅞	37	31	25	21	17	14	12	10	.....	.....	.....	.....	.....	14.09	43.96
	1	42	35	28	23	19	16	13	11	.....	.....	.....	.....	.....	15.71	49.01
	1⅛	47	40	32	26	22	18	14	12	.....	.....	.....	.....	.....	17.23	53.76
7	⅝	36	31	26	22	19	16	13	11	.....	.....	.....	.....	.....	12.52	39.06
	¾	42	36	31	26	22	19	16	13	11	10	.....	.....	.....	14.73	45.96
	⅞	48	41	35	29	25	21	18	15	13	11	.....	.....	.....	16.84	52.54
	1	54	46	39	33	29	24	20	17	14	12	.....	.....	.....	18.85	58.90
	1⅛	60	52	44	37	32	27	23	19	16	13	.....	.....	.....	20.76	64.77
8	¾	51	45	39	34	29	25	22	19	16	14	.....	.....	.....	17.08	53.29
	⅞	59	52	45	39	34	29	25	22	19	16	.....	.....	.....	19.59	61.12
	1	66	58	51	44	38	33	28	24	21	18	.....	.....	.....	21.99	68.64
	1⅛	73	64	56	48	42	36	31	26	23	20	.....	.....	.....	24.30	75.82
	1¼	79	70	61	52	45	39	34	29	25	22	.....	.....	.....	26.51	82.71
	1⅜	86	76	66	57	48	42	37	33	27	24	.....	.....	.....	28.62	89.29
9	¾	60	54	49	43	37	33	29	24	22	20	18	16	.....	19.44	60.65
	⅞	69	63	56	49	43	38	33	29	26	23	20	18	15	22.33	69.97

TABLE OF SAFETY LOAD OF CAST IRON COLUMNS.

(CONTINUED.)

Outside Diameter in inches.	Thickness of Metal.	LENGTH OF COLUMNS IN FEET. BOTH ENDS TURNED.													Sectional area in inches.	Weight in lbs. of Columns per foot of length.
		6	8	10	12	14	16	18	20	22	24	26	28	30		
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.		
9	1	78	71	63	55	48	42	37	33	29	26	23	20	17	25.18	78.40
	1⅛	87	78	69	62	53	47	41	36	32	29	25	22	19	27.83	86.88
	1¼	95	85	76	67	58	51	45	39	35	32	28	25	22	30.43	94.94
	1⅜	102	92	82	72	63	55	48	43	39	35	31	27	23	32.94	102.77
	1½	110	99	88	78	68	59	52	46	42	38	34	30	26	35.34	110.26
	1⅝	118	106	94	84	73	63	56	49	45	41	37	33	29	37.65	117.47
	1¾	126	113	100	90	78	67	60	51	48	44	40	36	32	39.86	124.36
10	⅞	80	73	67	60	53	47	42	37	34	30	27	24	21	25.09	78.28
	1	90	83	75	67	60	53	47	42	38	34	30	27	24	28.28	88.28
	1⅛	100	92	83	74	66	58	52	47	42	38	34	30	26	31.37	97.87
	1¼	110	101	91	82	73	64	57	51	47	42	38	33	28	34.37	107.23
	1⅜	119	109	98	88	79	69	62	55	51	46	41	36	31	37.26	116.25
	1½	128	117	106	95	85	75	67	59	54	49	44	39	34	40.06	124.99
	1⅝	146	133	122	109	97	85	77	67	60	56	50	45	40	45.36	141.52
11	1	102	95	87	79	71	64	58	52	48	43	38	34	30	31.42	98.08
	1⅛	114	105	96	88	79	71	64	58	53	48	42	37	32	34.90	108.89
	1¼	125	116	106	97	87	78	70	63	58	52	46	41	35	38.29	119.46
	1⅜	135	126	115	105	94	85	76	68	62	56	50	44	38	41.58	129.73
	1½	146	136	124	113	102	92	82	74	68	61	54	48	43	44.77	139.68
	1¾	166	156	142	129	118	106	94	86	79	71	62	56	49	50.86	158.68
	2	186	176	160	147	134	120	106	98	90	81	70	64	55	56.55	176.44
12	1	116	107	97	92	83	76	69	62	58	53	48	44	40	34.46	107.51
	1⅛	128	119	108	102	92	84	78	69	63	58	53	48	43	38.84	119.62
	1¼	141	131	119	112	101	93	84	76	70	64	58	52	46	42.12	131.41

TABLE OF SAFETY LOAD OF CAST IRON COLUMNS.

(CONTINUED.)

Outside Diameter in inches.	Thickness of Metal.	LENGTH OF COLUMNS IN FEET. BOTH ENDS TURNED. 6	8	10	12	14	16	18	20	22	24	26	28	30	Sectional area in inches.	Weight in lbs. of Columns per foot of length.
		Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.		
12	1⅜	153	142	129	121	110	101	91	82	75	69	62	56	50	45.80	142.90
	1½	165	154	139	131	119	109	99	89	82	75	68	60	53	49.39	154.10
	1¾	189	178	159	150	137	125	115	103	94	85	78	68	60	56.26	175.53
	2	213	201	179	170	155	141	131	117	108	96	88	76	67	62.74	195.75
13	1	127	119	111	104	97	90	81	73	67	61	56	51	46	37.67	117.53
	1⅛	142	134	126	117	109	101	91	82	75	69	63	58	52	41.94	130.85
	1¼	158	149	140	130	121	112	101	91	84	77	70	64	58	46.11	143.86
	1⅜	174	163	154	144	133	122	111	101	93	84	78	70	64	50.19	156.59
	1½	190	178	168	157	145	133	121	110	101	92	85	77	70	54.16	168.98
	1¾	214	201	189	176	164	151	137	124	114	104	95	87	78	61.82	192.88
	2	237	224	210	195	182	168	152	137	126	116	105	96	87	69.09	215.56
14	1	138	131	125	117	109	101	92	85	78	72	66	61	56	40.9	127.60
	1⅛	153	145	139	130	121	112	103	94	87	80	73	68	62	45.5	141.06
	1¼	168	160	158	148	133	123	113	104	95	88	80	74	68	50.1	156.31
	1⅜	188	174	167	156	145	134	123	113	104	95	87	81	74	54.5	170.04
	1½	198	189	180	168	156	145	133	122	112	108	94	87	80	58.87	183.67
	1¾	226	216	206	192	179	166	152	140	128	118	107	99	91	67.31	210.00
	2	254	242	232	216	201	186	171	157	143	132	120	111	102	75.36	235.12
15	1	150	148	136	128	120	112	104	97	90	83	76	71	65	44.00	137.28
	1⅛	167	159	152	143	136	125	116	108	100	93	85	78	72	49.1	153.19
	1¼	184	175	167	157	148	138	128	119	110	102	93	84	79	54.0	168.48
	1⅜	201	191	182	172	161	151	140	130	120	111	102	93	87	58.9	183.77
	1½	217	207	197	186	175	163	151	141	130	120	110	102	94	63.7	198.74
	1¾	248	236	225	212	202	190	175	160	148	137	126	115	107	72.9	227.45

Crushing and Tensile Strength, in lbs., per square inch of Natural and Artificial Stones.

DESCRIPTION.	Weight per Cubic ft in lbs	Crushing Force, Lbs. per Square Inch.
Aberdeen Blue Granite	164	8,400 to 10,914
Quincy Granite	166	15,300
Freestone, Belleville		3,522
Freestone, Caen		1,088
Freestone, Connecticut		3,319
Sandstone, Acquia Creek, used for Capitol Washington		5,340
Limestone, Magnesian, Grafton, Ill		17,000
Marble, Hastings, N. Y		18,941
Marble, Italian		12,624
Marble, Stockbridge, City Hall, N. Y		10,382
Marble, Statuary		3,216
Marble, Veined	165	9,681
Slate		9,300
Brick, Red	135.5	808
Brick, Pale Red	130.3	562
Brick, Common		800 to 4,000
Brick, Machine Pressed		6,222 to 14,216
Brick, Stock		2,177
Brick-work, set in Cement, bricks not very hard,		521
Brick, Masonry, Common		500 to 800
Cement, Portland		1,000 to 8,300
Cement, Portland, Cement 1, Sand 1		1,280
Cement, Roman		342
Mortar		120 to 240
Crown Glass		31,000
		TENSION.
Portland Cement		427 to 711
Portland Cement, with Sand		92 to 284
Glass, Plate		9,420
Mortar		50
Plaster of Paris		72
Slate		11,000

Capacity of Cylindrical Cisterns.

FOR EACH FOOT OF DEPTH.

Diameter in Feet.	Gallons.	Pounds.	Diameter in feet.	Gallons.	Pounds.
2.0	23.5	196	9.0	475.9	3,968
2.5	36.7	306	9.5	530.2	4,420
3.0	52.9	441	10.0	587.5	4,899
3.5	72.0	600	11.0	710.9	5,928
4.0	94.0	784	12.0	846.0	7,054
4.5	119.0	992	13.0	992.9	8,280
5.0	146.9	1,225	14.0	1,151.5	9,602
5.5	177.7	1,482	15.0	1,321.9	11,023
6.0	211.5	1,764	20.0	2,350.1	19,596
6.5	248.2	2,070	25.0	3,672.0	30,620
7.0	287.9	2,401	30.0	5,287.7	44,093
7.5	330.5	2,756	35.0	7,197.1	60,016
8.0	376.0	3,135	40.0	9,400.3	78,388
8.5	424.5	3,540	----	------	------

PROPERTIES OF TIMBER.

DESCRIPTION.	Weight per Cubic Foot in lbs.	Weight per foot B. M. in lbs., average	Tensile strength per sq. in., in lbs.	Crushing strength per sq. in., in lbs.	Relative strength for cross breaking. White Pine = 100.	Shearing strength with the grain, lbs. per sq. in.	Pressure in lbs. per sq. in. to indent 1-20
Ash	43 to 55.8	4.1	11,000 to 17,207	4,400 to 9,363	120 to 130	458 to 700	1,800 to 1,850
Beech	43 to 53.4	3.9	11,500 to 18,000	5,800 to 9,363	100 to 104	......	......
Cedar	50 to 56.8	4.5	10,300 to 11,400	5,600 to 6,000	55 to 63	......	......
Cherry	......	......	......	......	130	......	......
Chestnut	33	2.75	10,500	5,350 to 5,600	96 to 123	......	......
Elm	34 to 36.7	2.9	13,400 to 13,489	6,831 to 10,331	96	......	......
Hemlock	......	......	8,700	5,700	88 to 95	......	......
Hickory	......	......	12,800 to 18,000	8,925	150 to 210	......	......
Locust	44	3.7	20,500 to 24,800	9,113 to 11,700	132 to 227	......	......
Maple	49	4.1	10,500 to 10,584	8,150	122 to 220	367 to 647	1,700 to 1,900
Oak, White	45 to 54.5	4.1	10,253 to 19,500	4,684 to 9,509	130 to 177	752 to 966	2,300 to 3,550
Oak, Live	70	5.8	......	6,850	155 to 189	......	......
Pine, White	30	2.5	10,000 to 12,000	5,000 to 6,650	100	225 to 423	875 to 1,160
Pine, Yellow	28.8 to 33	2.6	12,600 to 19,200	5,400 to 9,500	98 to 170	286 to 415	1,900
Spruce	......	......	10,000 to 19,500	5,050 to 7,850	86 to 110	253 to 374	875 to 1,0[illegible]
Walnut, Black	42	3.5	9,286 to 16,000	7,500	......	......	[illegible],200 to 2,[illegible]

SQUARE CAST IRON COLUMNS.

Safe Load in Pounds. Safety 6.

BOTH ENDS TURNED.

Length.	Outside Size Column, 8x8.			Length.	Outside Size Column, 10x10.		
	¾ in.	1 in.	1½ in.		¾ in.	1 in.	1½ in.
8	255,485	328,902	458,113	10	325,965	422,874	599,071
9	247,656	318,822	444,073	11	318,015	412,560	584,460
10	239,457	308,266	429,370	12	309,751	401,839	569,272
11	231,785	298,430	415,670	13	301,232	390,787	553,615
12	222,400	286,308	898,787	14	292,540	379,512	537,662
13	213,752	275,176	383,280	15	283,752	368,111	521,790
14	204,896	263,774	267,399	16	274,925	356,659	505,267
15	196,642	253,153	252,606	17	266,109	345,229	489,075
16	188,268	242,368	337,584	18	257,362	333,875	472,989
17	180,126	231,887	322,986	19	248,709	322,650	457,087
18	172,220	221,709	308,810	20	240,204	311,616	441,456
19	164,589	211,884	295,125	21	231,873	300,809	426,146
20	157,242	202,426	281,950	22	223,720	290,232	411,162
21	150,225	193,354	269,314	23	215,881	280,062	396,754
22	148,452	184,674	257,224	24	208,083	269,946	382,423
23	137,014	176,376	245,552	25	200,619	260,263	368,704
24	130,881	168,490	234,682	26	193,398	250,895	355,434
25	125,349	160,809	223,985	27	186,411	241,830	342,592
	Outside Size Column, 12x12.				**Outside Size Column, 12x12.**		
	1 in.	1½ in.	2 in.		1 in.	1½ in.	2 in.
12	516,846	740,029	939,720	21	414,986	594,184	754,520
13	506,383	725,048	920,696	22	403,458	577,678	733,560
14	495,550	709,537	901,000	23	392,093	561,406	712,896
15	484,418	693,598	880,765	24	380,864	545,328	692,480
16	473,057	677,332	860,104	25	369,829	529,527	672,416
17	461,579	660,838	839,160	26	359,005	514,030	652,736
18	449,913	644,194	818,024	27	348,401	498,847	633,456
19	438,253	627,499	796,824	28	337,731	483,569	614,056
20	426,593	610,804	775,624	29	329,941	469,552	596,256

COST OF LIVING IN CHINA.

Land in China is divided into more holdings than any other land in the world. It takes but a very small piece of land to support a Chinese family. The Chinese are the closest and most thorough cultivators in the world. Field hands in China are paid $12 per annum. The food is cooked by the employer. With his food he is furnished straw, shoes and free shaving — the last a matter which a Chinaman never neglects for any great length of time where it is possible to secure the luxury. It costs about $4 a year to clothe a Chinaman. Much of the land in China is divided up into gardens of areas as small as one-sixth of an acre.

NOTES ON HOT WATER SYSTEMS.

Let your "risers" not be less than 1¼", for smaller pipes soon become coated, if the water used contains lime or other matters in solution or suspension.

Galvanized pipe is best; it does not become rusty and discolor the water.

In ordinary pipe be sure to get "galvanized steam," and not "galvanized gas."

Let your draw-off services be for bath 1", to lavatories 1", for hot water ½". Do not make the "draw-offs" too small, it takes too long to drain a pipe of cold water.

The larger the pipes the freer the circulation, and, if you have hard water, they will remain in good order longer.

Be sure that all joints are secure and free from leaks, and always look through a pipe before fitting it in place, to see that there is no dirt or impediment to the flow of the water through it.

Avoid the use of elbows in circulating pipes, use only bends; if you cannot avoid using an elbow, see that it is a round one.

TO SOLDER ALUMINUM.

M. Bourbouze has formed an alloy of 45 parts of tin and 55 parts of aluminum, which answers for soldering aluminum. This alloy possesses almost the same lightness as the pure aluminum, and can be easily soldered. M. Bourbouze has invented another containing only ten per cent. of tin. This second alloy, which can replace aluminum in all its applications, can be soldered to tin, while it preserves all the principal qualities of the pure metal.

A new and curious alloy is produced by placing in a clean crucible an ounce of copper and an ounce of antimony, and fusing them by a strong heat. The compound will be hard, and of a beautiful violet hue. This alloy has not yet been applied to any useful purpose, but its excellent qualities, independent of its color, entitle it to consideration.

A CHEAP FILTER.

A cheap filter which any tinner can make is 12x6 inches in size, and 8 inches high. The water flows in near the top, and on the top is a door through which to get into it to clean it. The outlet pipe at the bottom projects two inches up on the inside to hold the dirt back. A large sponge is placed inside, which forms the filtering medium, which, of course, can be cleaned as often as desired.

COMPOSITION OF BABBITT METAL.

Genuine Babbitt metal, according to the formula of the inventor, is 9 of tin, 1 of copper. Antimony has been added since, so that the proportions by hundreds will stand 80 tin, 5 copper, 15 antimony. For high speeds the metals should be cooler, giving a larger proportion of tin; for weight the metal should be harder, giving a larger proportion of antimony.

THE HEATING SURFACE OF A STEAM RADIATOR.

For instance, the radiator contains 300 feet of one-inch pipe; what will be its heating surface in square feet? A. 300 feet = 3,600 inches. The outside circumference of one-inch pipe = 4 inches. And 3,600 × 4 = 14,400 square inches of heating surface. Lastly,

$$\frac{14{,}400}{144} = 100$$

square feet of heating surface. The way you have calculated the heating surface is not correct, because you did not multiply the length of the pipe by the circumference.

A CHIMNEY THAT WILL DRAW.

To build a chimney that will draw forever, and not fill up with soot, you must build it large enough, sixteen inches square; use good brick, and clay instead of lime up to the comb; plaster it inside with clay mixed with salt; for chimney tops use the very best of brick, wet them and lay them in cement mortar. The chimney should not be built tight to beams and rafters; there is where the cracks in your chimney comes, and where most of the fires originate, as the chimney sometimes get red hot. A chimney built from the cellar up is better and less dangerous than one hung on the wall.

ANCIENT USE OF LEAD.

The ancients, like the moderns, used lead to fasten iron into stone, to give a glaze to pottery, and as a help to the manufacture of glass. Very singular were the "imprecation tablets, surreptitiously deposited in tombs, and sometimes even in the coffin of the deceased, that a curse might follow him to the other world," which seem "to have been more frequently deposited by women than by men." Vitruvius describes elaborately a vast aqueduct, the lead in which

would cost to-day two millions. The leaden bullets of the ancient slingers often bore an inscription in relief, such as "Appear," "Show yourself," "Desist," "Take this," "Strike Rome." The Greeks were especially fond of bullets with such mottoes, and they have been found upon Marathon and many other famous fields.

A RUSSIAN WELDING PROCESS.

The process of welding, invented by Mr. De Benardox, of Russia, is now applied industrially by the Society for the Electrical Working of Metals. The pieces to be welded are placed upon a cast-iron plate supported by an insulated table, and connected with the negative pole of a source of electricity. The positive pole communicates with an electric carbon inserted in an insulating handle. On drawing the point of the carbon along the edges of the metal to be welded, the operator closes the circuit. He has then merely to raise the point slightly to produce a voltaic arc, whose high temperature melts the two pieces of metal and causes them to unite. The intensity of the current naturally varies with the work to be done. For regulating it, a battery of accumulators is used, and the number of the latter is increased or diminished as need be. This process of welding is largely employed in the manufacture of metallic tanks and reservoirs.

COLD SOLDER.

La Metallurgie gives the following receipt for cold solder: Precipitate copper in a state of fine division from a solution of sulphate of copper by the aid of metallic zinc. Twenty or thirty parts of the copper are mixed in a mortar with concentrated sulphuric acid, to which is afterward added seventy parts of mercury, and the whole triturated with the pestle. The amalgam produced is copiously washed with water to remove the sulphuric acid, and is then left for twelve hours. When it is required for soldering, it is warmed until it is about the consistency of wax, and in this state it is applied to the joint, to which it adheres on cooling.

TO TIN MALLEABLE IRON.

W. M. writes: I tin malleable iron, which comes from the bath nice and bright, but although I keep it covered, after a few days it gets red, copper colored in spots, and this color gradually spreads all over the work. Can you tell me the cause? A.—The red color is probably derived from oxida-

tion of the iron by the acid left in the pores of the iron. The acid rusts the iron and oozes out through the pores of the tin by the pressure due to increase of bulk by the action of the acid upon the iron; possibly also moisture may be absorbed by the acid through the tin, which is porous. Rinse the work immediately after tinning in boiling water, holding 2 oz. sal soda to the gallon in solution.

OLD TINS NO LONGER USELESS.

A number of people recently gathered at the Columbia rolling mill, Fourteenth street and Jersey avenue, Jersey City, at the formal opening of the mill. The industry is a novel one, being the manufacture of taggers' iron from old tin cans, and other waste sheet metal. This iron has heretofore been manufactured almost exclusively in Europe, and the Columbia Rolling Mill Company is the only American company which turns out the product in large quantities. The process is simple. The tin cans are first heated in an oven raised to a temperature of about 1,000°, which melts off the tin and lead. The sheet iron which remains is passed first under rubber-coated rollers, and then chilled iron rollers, which leaves the sheet smooth and flat. After annealing and trimming, they are ready for shipment. The tin and lead which is melted from the cans is run into bars, and is also placed upon the market. All the raw material used is waste, but the sheet iron turned out is said to be of good quality. It is used for buttons, tags, and objects of a like nature. The material used costing little, and the demand for taggers' iron being considerable, it is thought that this is a good opportunity to build up another American industry.

LEAD ON ROOFS AND IN SINKS.

Tenacity is very slight in some of the metals. An instance may be seen where roofs are covered with lead. The heat of the sun will expand them, and, of course, it is easier for the sheets to expand down-hill than up; then, when they get cold, their own weight will be too great for them, and they will sooner stretch than creep back up hill; so, in fact, unless properly laid, the lead roof will to some extent crawl off its frame-work. The same thing will be seen in kitchen sinks of lead, where very hot water is run into them. The lining gets wrinkled, because, after buckling by reason of the expansion, it will sooner pull thinner than come back to the ordinary position and condition of surface.

THE USE OF THE STEEL SQUARE.

The standard steel square has a blade 24 inches long and 2 inches wide, and a tongue from 14 to 18 inches long and 1½ inches wide. The blade is exactly at right angles with the tongue, and the angle formed by them an exact right angle, or square corner. A proper square should have the ordinary divisions of inches, half inches, quarters and eighths, and often sixteenths and thirty-seconds. Another portion of the square is divided into twelfths of an inch; this portion is simply a scale of 12 feet to an inch, used for any purpose, as measuring scale drawings, etc. The diagonal scale on the tongue near the blade, often found on squares, is thus termed from its diagonal lines. However, the proper term is centesimal scale, for the reason that by it a unit may be divided into 100 equal parts, and therefore any number to the 100th part of a unit may be expressed. In this scale A B is one inch; then, if it be required to take off 73-100 inches, set one foot of the compasses in the third parallel under 1 at E, extend the other foot to the seventh diagonal in that parallel at G, and the distance between E G is that required, for E F is one inch and F G 73 parts of an inch.

Upon one side of the blade of the square, running parallel with the length, will be found nine lines, divided at intervals of one inch into sections or spaces by cross lines. This in the plank, board and scantling measure. On each side of the cross lines referred to are figures, sometimes on one side of the cross line, and often spread over the line, thus, 1 | 4—9 | — We will suppose we have a board 12 feet long and 6 inches wide. Looking on the outer edge of the blade we find 12; between the fifth and sixth lines, under 12, will be found 12 again; this is the length of the board. Now follow the space along toward the tongue till we come to the cross line under 6 (on the edge of the blade), this being the width of the board; in this space will be found the figure 6 again, which is the answer in board measure, viz., six feet.

On some squares will be found on one side of the blade 9 lines, and crossing these lines diagonally to the right are rows of figures, as seven 1s, seven 2s, seven 3s, etc. This is another style of board measure and gives the feet in a board according to its length and width.

In the center of the tongue will generally be found two parallel lines, half an inch apart, with figures between them; this is termed the Brace Rule. Near the extreme end of the tongue will be found 24-24 and to the right of these 33.95. The 24-24 indicate the two sides of a right-angle-triangle, while the length of the brace is indicated by 33.95. This will explain the use of any of the figures in the brace rule. On the opposite side of the tongue from the brace rule will generally be found the octagon scale, situated between two central parallel lines. This space is divided into intervals and numbered thus: 10, 20, 30, 40, 50, 60. Suppose it becomes necessary to describe an octagon ten inches square; draw a square ten inches each way and bisect the square with a horizontal and perpendicular center line. To find the length of the octagon line, place one point of the compasses on any of the main divisions of the scale and the other leg or point on the tenth subdivision.

ENDLESS TIN PLATES.

A patent has been recently granted for a novel process of manufacturing continuous tin plates. The plates are made of steel, and the process consists of producing a sheet of steel of any continuous length and of required width, by first rolling the metal hot and afterward rolling it cold, until a proper thickness and perfectly smooth surface is obtained. Next, the surface of the sheet is scoured, and then it is afterward passed through a bath of molten tin, thus receiving its coating. Finally the sheet is subjected to a rolling operation, under heavy pressure, between highly polished rolls, by which the tin and steel are condensed and consolidated together, and the surface hardened and polished. The inventor states that, by this method, the tin will be found to be so hardened upon and incorporated with the steel, as to produce a tin plate which is superior, in most respects, to any tin plate, wherever produced.

ORIGIN OF PORCELAIN.

The Chinese, the pioneers in the art of porcelain manufacture, began to make it nearly two centuries before the Christian era, and so careful were they to guard the secret of the art that nearly fifteen centuries lapsed before their neighbors, the Japanese, got any inkling of it. But once in their possession, the wily Japanese lost no time to profit by their knowledge. The few intrepid navigators of those days brought samples of both Chinese and Japanese ware to Europe, but not until early in the sixteenth century did a trade in it of any extent take place. Among the early importers were Portuguese traders, and to them, we owe the word porcelain, derived from the Portuguese porcellana, or sucking pig. When the Portuguese traders first saw pieces of Japanese ware they were struck with its translucence, which somewhat resembled that of the cowry shell. The cowry shell resembled a small sucking pig, hence our "porcelain."

CRYSTALLIZED TIN PLATE.

Crystallized tin plate has a variegated primrose appearance, produced upon the surface by applying to it, in a heated state, some dilute nitro-muriatic acid for a few seconds, then washing it with water, drying, and coating it with lacquer. The figures are more or less diversified, according to the degree of heat and relative dilution of the acid. Place the tin plate, slightly heated, over a tub of

water, and rub its surface with a sponge dipped in a liquid composed of four parts of aquafortis and two of distilled water, holding one common salt or sal-ammoniac in solution. When the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, washed either with a feather or a little cotton, taking care not to rub off the film of tin that forms the feathering, forthwith dried with a low heat, and coated with a lacquer varnish, otherwise it loses its luster in the air. If the whole surface is not plunged at once in cold water, but is partially cooled by sprinkling water on it, the crystallization will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state.

USEFUL RECIPES.

Tinning Acid for Zinc or Brass.—Zinc. 3 oz.; muriatic acid, 1 pt. Dissolve, and add 1 pt. water and 1 oz. sal-ammoniac.

To Solder Brass Easily.—Cut out a piece of tin foil the size of the surface to be soldered. Then apply to the surface a solution of sal-ammoniac for a flux. Place the tin foil between the pieces, and apply a hot soldering-iron until the tin foil is melted.

To Solder Without Heat.—Steel filings, 2 oz.; brass filings, 2 oz.; fluoric acid, 1¼ oz. Dissolve the filings in the acid, and apply to the parts to be soldered, having first thoroughly cleaned the parts to be connected. Keep the fluoric acid in earthen or lead vessels only.

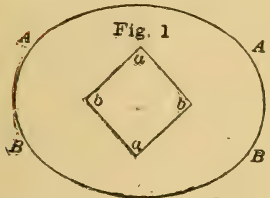
To Tin Brass and Copper.—Make a mixture of 3 lbs. cream of tartar, 4 lbs. tin shavings, and 2 gallons water, and boil. After the mixture has boiled sufficiently, put in the articles to be tinned, and continue the boiling. The tin will be precipitated on the articles.

TO POLISH NICKEL-PLATE.

To brighten and polish nickel-plating and prevent rust, apply rouge with a little fresh lard or lard oil on a wash-leather or piece of buckskin. Rub the bright parts, using as little of the rouge and oil as possible: wipe off with a clean rag slightly oiled. Repeat the wiping every day and the polishing as often as necessary.

PATTERN FOR FLARING OVAL ARTICLES.

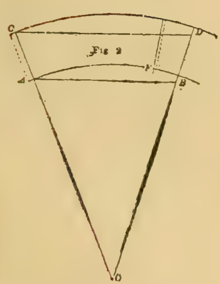
Of all the great variety of patterns with which the tin man has to deal, there is probably none that seems more difficult and causes more trouble and perplexity to make than a flaring oval pan. By following the annexed diagrams and explanations, the development of this pattern will be seen to be simple, easy and quickly performed.

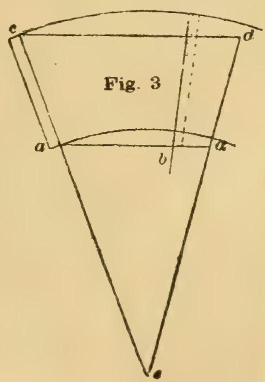


First, always describe the oval from two centers — thus making the bottom of the dish — parts of two diameters or circles. Separate the circles when they intersect each other, and proceed the same as in any round, flaring article.

In Fig. 1 the compasses are set at *a a*, and the large circles described as A A B B, then set the compasses at *b b* and describe the smaller circles, thus completing the oval or bottom of pan.

To make the pattern for the body: In Fig. 2 mark A B





the size of large diameter. Then draw the depth of vessel and flare desired, as A B C D. Extend the lines C A and

D B until they cross at *e*, set the compasses at *e*, and describe the curved lines C D and A B. Make the length A F equal to A A in Fig. 1. Add the locks as shown in dotted lines; this will be the pattern for side of dish.

In Fig. 3, make *a a* equal to the small diameter and proceed the same as in Fig. 2, this will be the end pattern. It takes two pieces of the large pattern and two of the small to

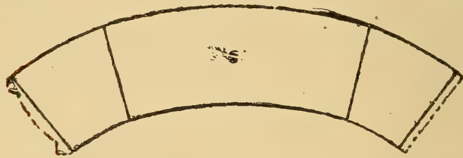
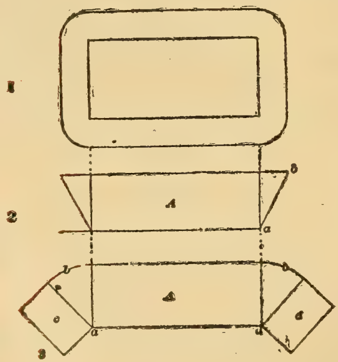


FIG 4.

make the dish. Should it be found desirable to make the body of pan in only two pieces, then cut the smaller or end pattern in two and place it upon each side of the large pattern, as shown in Fig. 4.

An oval can be made from three or more centers upon the same plan when desired.

FLARING ARTICLES WITH ROUND CORNERS.



First, to cut the pattern of an oblong flaring dish with square-cornered bottom and round cornered top, in two pieces, of which Fig. 1 is the ground plan, and Fig. 2 the side elevation.

The height of side A, Fig. 2, is from *a* to *b*; which is also the radius for the corners. First mark off the side A, Fig. 3; then strike the segments of the circles *a b*; this gives the corner. Then

mark off one-half of end on each side of a b (c and d), which completes the pattern for one-half the dish.

Fig. 4.

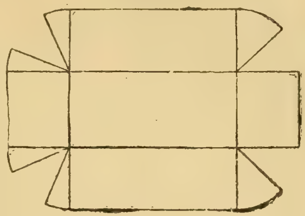
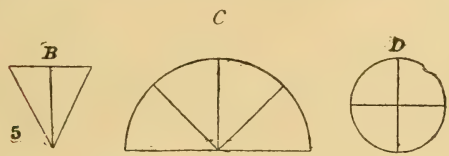


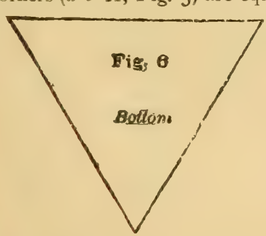
Fig. 4. For practice, we will now cut the pattern so the bottom, sides and corners will be in one piece.

One end of the seam comes on the end piece, and on the other end in the center of the corner piece.

Fig. 5, B, shows cone made by putting together the two flaring sides shown in Fig. 2, A and C, the pattern required to construct said cone D is the ground plan of cone B



divided into four parts. It will be noticed that the four corners in Fig. 1 will make D, and that the pattern for the four corners (a b A, Fig. 3) are equal to C, Fig. 5.



As each corner of Fig. 1 is one-fourth of a cone, so the pattern of each corner, Fig. 4, is one-fourth of the pattern C, required to make the cone B, Fig. 5.

We will now suppose A, Fig. 2, to be the side view of a triangular dish constructed on the same princiciple as A. Each of the

sides will be the same size as required to make the square dish, only the pattern C, Fig. 5, will be required to be divided into three parts for each corner of the triangle. Fig. 6 is a ground plan of bottom of dish. We will cut this pattern in one piece by marking off one of the rides, and then transfering one-third of pattern

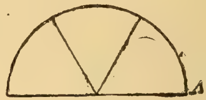
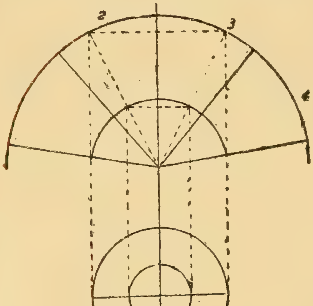


Fig. 8.

A, Fig. 7, to each side, until we have used the three sides and three corner pieces.

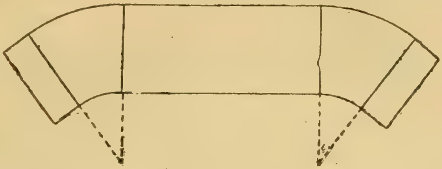
The next step will be to cut the pattern of a flaring oblong dish, top and bottom having round corners, of which Fig. 2 will be a side view, and A, Fig. 8, the ground plan.



If the side and end pieces in A, Fig. 8, were removed, B would be the result. C is a side view and pattern for B. Now, if we wish a pattern for the A, all that is required is to cut the pattern for the four corners (C) into four

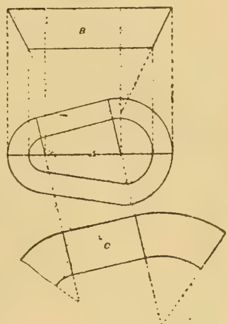
pieces, and place the side and end pieces between, or, if the

Fig. 9.



pattern is wanted in two pieces, take a side on which we place two corners and a half of an end against each corner, as follows:

Fig. 10



Or we can suppose Fig. 10, B, to be the side view of dish having half-round flaring ends, but ends of different diameters, as shown by Fig. 10, A.

We will have the small end the same as in Fig. 8, so as to use the same pattern.

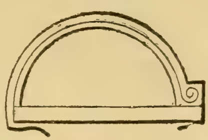
B, Fig. 10, showing side view and radius of large and small circle.

Fig. 10, C, giving the pattern for one-half of A, Fig. 10.

To have the drawings appear plain, locks were not added.

MAKING EAVE TROUGH.

The outside line on the larger of the two small diagrams represents a No. 9 spring wire clamp, one to be used at each seam of the trough. The dark line on outside of the smaller diagram represents a small clamp used to hold the bead down at the ends of the log. The

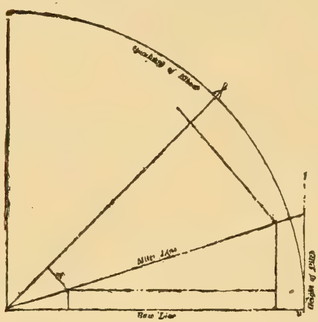


large diagram shows the log with the trough clamped to it. It will be seen that a ¾-inch piece is secured to the flat side of the log, which piece projects ¾ of an inch beyond one edge

of the log. A rocker may also be placed under the log. The log is secured to the bench by hooks or staples with a long shank fastened to the bench and hooking onto spikes driven into the ends of the log.

TABLE OF HEIGHT OF ELBOW ANGLES.

The following table gives the height of pitch of miter lines for elbows from one inch to twenty-five inches in diameter. It will be found of great assistance in describing elbow patterns quickly and accurately, by doing away with drawings and geometrical calculations, which would otherwise be necessary to get the correct pitch of elbows. The accompanying diagram indicates the position of base and miter lines. The height of pitch, that is, the length from O



to W, is shown by the table for all elbows from one inch to twenty-five inches in diameter, and of from two to ten pieces. In two-piece elbows the height of pitch is the diameter of the elbow, and this column is added to make the table complete. No matter how large the sweep of an elbow, the angle of pitch remains the same, and the only difference to be made in cutting the pattern is to add space as desired, as indicated at X in the diagram. Locks and seams are to be added.

Size in inches	NO. OF PIECES IN ELBOW.								
	2	3	4	5	6	7	8	9	10
1	1	7-16	9-32	7-32	6-32	5-32	1-8	1-8	3-32
2	2	27-32	18-32	13-32	11-32	9-32	1-4	7-32	6-32
3	3	1 1-4	13-16	5-8	1-2	7-16	11-32	5-16	9-32
4	4	1 21-32	1 1-16	13-16	21-32	9-16	15-32	13-32	3-8
5	5	2 1-16	1 5-16	1	13-16	11-16	9-16	1-2	7-16
6	6	2 1-2	1 5-8	1 3-16	31-32	13-16	11-16	5-8	9-16
7	7	2 29-32	1 7-8	1 3-8	1 1-8	15-16	13-16	9-16	5-8
8	8	3 5-16	2 1-8	1 9-16	1 1-4	1 1-16	29-32	13-16	23-32
9	9	3 23-32	2 13-32	1 13-16	1 7-16	1 3-16	1	29-32	13-16
10	10	4 1-8	2 11-16	2	1 9-16	1 5-16	1 1-8	1	29-32
11	11	4 1-2	2 15-16	2 3-16	1 3-4	1 7-16	1 1-4	1 3-32	1
12	12	4 15-16	3 3-16	2 3-8	1 7-8	1 9-16	1 3-8	1 3-16	1 1-16
13	13	5 3-8	3 7-8	2 9-16	2 1-16	1 23-32	1 15-32	1 5-16	1 5-32
14	14	5 3-4	3 23-32	2 3-4	2 7-32	1 7-8	1 9-16	1 3-8	1 1-4
15	15	6 5-32	4	2 31-32	2 3-8	2	1 11-16	1 1-2	1 11-32
16	16	6 19-32	4 1-4	3 5-32	2 17-32	2 1-8	1 13-16	1 19-32	1 7-16
17	17	7	4 7-32	3 6-16	2 11-16	2 1-4	1 15-16	1 11-16	1 1-2
18	18	7 3-8	4 25-32	3 9-16	2 27-32	2 3-8	2 1-32	1 25-32	1 19-32
19	19	7 13-16	5 1-16	3 3-4	3	2 1-2	2 1-8	1 7-8	1 11-16
20	20	8 1-4	5 5-16	3 31-32	3 3-16	2 21-32	2 1-4	2	1 25-32
21	21	8 5-8	5 19-32	4 5-32	3 11-32	2 13-16	2 3-8	2 1-16	1 7-8
22	22	9 1-16	5 27-32	4 3-8	3 1-2	2 15-16	2 1-2	2 3-16	1 15-16
23	23	9 7-16	6 3-32	4 9-16	3 21-32	3 1-16	2 19-32	2 9-32	2 1-32
24	24	9 7-8	6 3-8	4 3-4	3 13-16	3 3-16	2 11-16	2 3-8	2 1-8
25	25	10 9-32	6 5-8	4 15-16	3 15-16	3 5-16	2 13-16	2 7-16	2 3-16

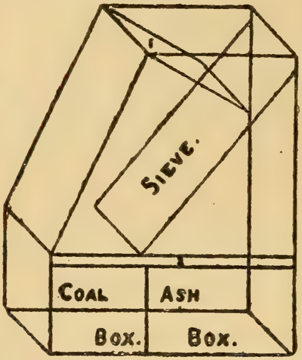
The table is adapted to right-angled elbows only. The line of figures at the top of the table indicate the number of pieces of which elbows are to be made. All other figures are in inches, the first or left hand column being the diameter of elbows, the remaining column being the height of pitch required.

ZINC AS A FIRE EXTINGUISHER.

Zinc, placed upon the stove, in fire or in grate, is said to have proved itself an effective extinguisher of chimney fires. To a member of the Boston Fire Department is reported to be due the credit of successfully introducing this simple scheme. When a fire starts inside a chimney, from whatever cause, a piece of tin sheet zinc, about four inches square, is merely put into the stove or grate connecting with the chimney. The zinc fuses and liberates acidulous fumes, which, passing up the flue, are said to almost instantly put out whatever fire may be there. It certainly sounds simple enough.

HOME-MADE ASH SIFTER.

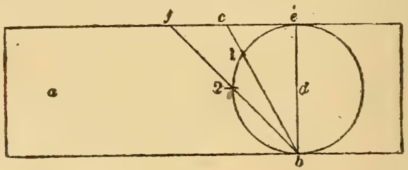
An Iowa correspondent sent *Good Housekeeping* the following diagram and description of a home-made ash-sifter, any tinner or other person may construct: "I got my idea of it from seeing sand sifted by throwing it on a sieve that stood slanting. The wire sieve (already wove) can be bought at a hardware store for twenty cents a running foot, and it is two or two and a half feet wide, and this can be tacked to a frame made to fit the sifter, one end just reaching over the box for coal, and the other end extending nearly to the top of the sifter. There is no shaking, nor any dust. Ashes are emptied in the top of the sifter, the coal being carried over the sieve to the coal box, while the ashes go through into the ash box. The sieve should be two and a half feet long. Can use a sliding or swinging cover."



TO DESCRIBE A MITER.

As there seems to be some interest manifested in regard to the miter question, and nothing definite as to the desired miter has been given, I wish to submit the following rule:

Let *a* in diagram be the size of the article upon which the miter is to be cut; strike a circle full size, or from edge to edge as shown at *e* and *b* of the diagram; draw a line as shown by *d*, from *e* to *b*, which divides the circle equally. If



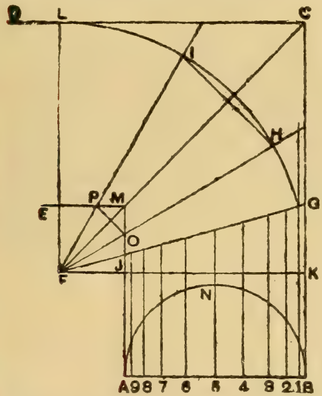
you wish a square miter set compass at *e* and obtain one-fourth of the circle as shown at figure 2, and draw line *b f*

intersecting the circle where the point of the compass shows one-fourth of circle. Cutting this line you have a square miter. Should you wish your work to form six squares, take the sixth of a circle as shown at figure 1 by line *c b;* or, if eight squares, one-eighth of circle, and intersect the circle at point designated by compass.

A miter may be cut for any angle desired by the same rule; divide the circle into the number of squares wanted, and proceed as shown above. This rule does not apply to forming a miter for gutters.

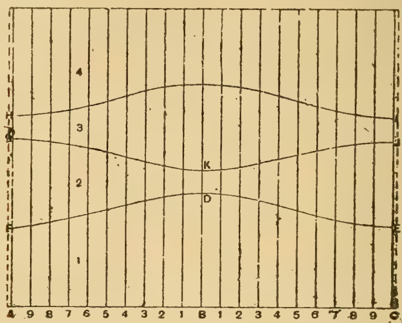
TO DESCRIBE A PATTERN FOR A FOUR-PIECE ELBOW.

Three and four piece elbows have very largely taken the place of the old right-angled elbow, on account of their better appearance, and also because they lessen obstruction to draft. The machine-made article is kept in stock for all common sizes, but the tinner is liable to be called upon at any time to make such an elbow, on account of stock being sold out or of unusual size, or other cause. Herewith are given diagrams and explanations which will enable any tinner to construct a pattern for any desired size.



Let A B E D, Fig. 1, be the given elbow; draw the line F C; make F M equal in length to one-half the diameter of the elbow, with F as a center; describe the arc K L; divide the arc K L into three equal parts; draw the lines F H and F I; also the line I H; divide the section H K into two equal parts, and draw the line F G; draw the line A B at right angles to B C; describe the semi-circle A N B; divide the semi-circle into any number of equal parts; from the points draw lines parallel to B C, as 1, 2, 3, etc.

Set off the line A B C, Fig. 2, equal in length to the circumference of elbow A B; erect the lines A F, B D and



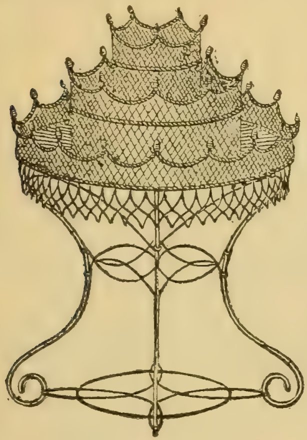
C E; set off on each side of the line B D the same number of equal distances as in the semi-circle A N B; from the points draw lines parallel to B D, as 1, 1, 2, 2, etc.; make B D equal to B G; make A F and C E equal to A J; also each of the parallel lines, bearing the same number as 1, 1, 2, 2, 3, 3, etc.; then a line traced through the points will form the first section; make F G and E J equal to H I; reverse section No. 1; place E at G and F at J; trace a line from G to J; make G H and J I equal to P O, Fig. 67, or to D K, Fig. 68; take Sec. No. 1, place F at H and E at I, and trace a line from H to I; this forms Sec. No. 3 and 4.

Edges to be allowed.

In the West Indies the work of coaling ships is performed by negresses. Like ants going to and fro, each of these women, with a load of coal weighing about forty pounds, carried in a basket on top of the head, climbs the gang-plank, and the bunkers are filled in a wonderfully short time. For this arduous work, a cent a basket is the general price, but night work and emergencies double the rate. A penny is given to each woman as she fills her basket, and the number given out forms a check on the tally kept by the parties receiving the coal. The name of the firm owning the coal pile is stamped on the coins, which are current throughout the slands.

A WIRE FLOWER STAND.

Tinners are ingenious, and can generally make anything from sheet metal, wire, or other light material, which they take a fancy to try their hands at. Many have made ornamental articles at odd moments with which to beautify their own home, or possibly that of some young lady. By their skill in this direction they are frequently able to make presents of articles of their own make, which are not merely ornamental, but also useful. This is commendable, and such skill and enterprise is worthy of encouragement.



We here present an illustration of a new round flower-stand constructed in three parts, which can be taken asunder so as to convert the stand at will into a rustic table. The cut is taken from the London *Ironmonger*, which says that the originator of the flower-stand is doing well with it.

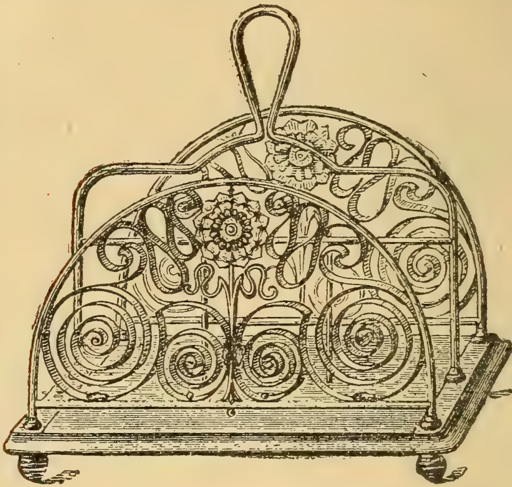
TO STRIKE AN OVAL OF ANY LENGTH OR WIDTH

In a recent number of the *American Artisan*, which I have mislaid, some one asks for a rule to strike an oval of any desired width and length. There are several different ways of striking an oval or ellipse, but I find the one I enclose you the most practical.

Let A B and C D equal width and length. On the line C D lay off the width of oval as C C. Divide the distance from E to D into three equal parts, and lay off two of the parts thus formed on either side of the center F, as G and H. Span the dividers from H to G, and, with F as a center, check the line A B, as at M and K. Draw line intersecting the points H M G K, and, with the radius G D and K B strike the ends and sides of oval.

AN ORNAMENTAL PAPER HOLDER.

Tinners with leisure who desire to use their handiwork in making something for Christmas, will be interested in the

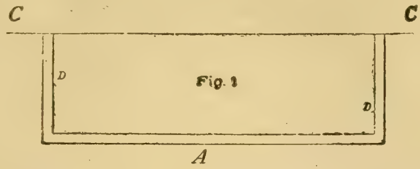


accompanying illustration which we reproduce from a European journal. It is intended for a holder for paper, magazines, or sheet music.

HEATING AND VENTILATION.

Much continues to be said and written about heating and ventilation, and some may consider it a worn-out subject; but so long as millions of people continue to be poisoned by impure air, agitation to secure reform cannot be overdone. It will do no harm, therefore, to again name some of the evidences and consequences of a lack of ventilation: Headache; dull pressure on the lungs; lungs become parched, producing irritation; dryness of the throat, producing sore throat; a feverish condition of the whole system. These are some of the immediate consequences, but by no means embrace

all the ultimate evil effects. It should be the duty of all furnacemen to call the attention of their patrons to these



matters. Furnaces are often blamed for the quality of air supplied, while the fault lies solely with the operators in not making provision for the supply of pure air to the furnace, and proper ventilation.

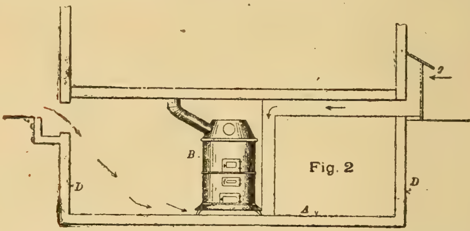
This subject will not take care of itself. We must first feel that fresh air is worth taking some trouble to obtain, and then we must study how to obtain it without the body's becoming either chilled or overheated in summer or winter, in the daytime or in the night. At night more care needs to be taken to secure ventilation, because there are no doors being opened; no stirring about to promote circulation. Especially should pure air be supplied to the sick room, and the vitiated air removed.

In summer we depend on the natural movement of the air for ventilation, windows and doors being open more or less. In winter, with the house closed up, it requires thought and effort to provide for a change of air in apartments. It must be remembered that, under natural conditions, air moves horizontally, according to the direction of the wind. Heat causes air to move in a perpendicular direction. In dry weather, heated air and smoke will rise until the same density of atmosphere is reached, which soon results from loss of heat. When the atmosphere contains a great deal of moisture, smoke will descend, on account of quick condensation and loss of heat.

This principle, understood by all must be kept in view in any plan for ventilation. Suppose we wish to ventilate a room in the morning when the air outside has become a little warmer than the air inside. The upper part of a window being opened the warmer air outside would blow across the top of the room, leaving the air below undisturbed. Now, if we open the window at the bottom we shall secure a circulation of air in the room. While the outside air is warmer we do not notice the draft. Suppose we now go into the kitchen, where the windows are only opened at the bottom and raised half way up; we shall feel the lower part is cool,

while the air in the upper part is undisturbed. Now, if we open the top of the window and divide the difference so as to have the top and bottom open, we shall have a circulation. Or if we open a door and hold a candle at the top and then at the bottom, we will see the same circulation illustrated by the cold air flowing in at the bottom and the hot air out at the top. These experiments furnish the natural laws which should govern ventilation.

Carbonic acid gas from respiration and other exhalations of the body, as well as gases caused by decayed vegetation in cellars, or from garbage, sewer emanations or any kind of



filth, are all poisonous, and, being heavier than pure air, sink to the bottom of a room by gravitation. It is a gross error to suppose, as many do, that the foul air rises to the ceiling and remains there. The sickness and death of children, often attributed to other causes, arises from blood-poisoning from the foul air near the floor to which children are much more exposed than grown persons.

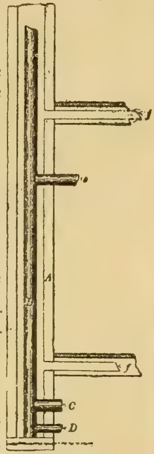
The illustrations given herewith will show where the foul air is and how it is confined unless drawn off by some superior force. In Fig. 1, *A* represents a cellar, *DD* the walls, *CC* the surface of the ground outside of the house. Foul air seeks the lowest space by gravitation, therefore all below *CC* is foul air because there is no ventilation to draw it away. So long as it remains stagnant, pure air will not take the place of the foul. Now, if we place a furnace in the cellar, as shown in Fig. 2, and take the air from the same, it would amount to almost the same thing as living in the cellar, for you breathe the same air. Opening the windows furnishes an outlet for the warm air and thus cools off the furnace; but the same foul air, dust and ashes are brought up from the furnace for inhalation.

Again, if the rooms are closed, the air from the furnace will rise to the ceiling, then pass to the windows, where the

temperature will be reduced, and will then descend to the floor and down the sides of the hot-air flue to the furnace to be reheated and sent up again. This has been proven by experiment. The children will be the first to be affected by this reheated foul air.

How can we obtain pure air? By ventilation. How can ventilation be secured? In various ways. The principal method used is the ventilating shaft. One shaft is generally sufficient for one dwelling, and is usually in the form of a large chimney, as shown in Fig. 3. *A* is the chimney; *B* is a heavy sheet-iron pipe, with air space around the pipe for ventilation; *C* is an opening into the pipe *B* for connection with the furnace; *D* is a place for cleaning out just below the furnace opening; these two openings should be in the cellar where the furnace is; *C* is the place for the kitchen stove, which will supply sufficient heat for ventilating the house during the summer season.

Fig. 3.



We will next consider how to supply the furnace with pure air. It should be taken from the side from which come the prevailing winds. Of course, care should be taken that it is not polluted by a sewage hopper, water closet or other source of containation. The opening into the air-duct should be two feet or more above the ground, and should be covered with fine wire gauze. The air-duct should be carried along the ceiling of the cellar until it reaches the furnace, as shown by dotted lines in Fig. 2, then drop down at the side of the furnace to the bottom. The space around the furnace should be made air-tight. Any foul air in the cellar will be drawn into the fire-box of the furnace to promote the combustion of the fuel. The area of the cold-air duct should, in no case, be less than half the area of the hot-air pipes.

In setting a furnace, particular care snould be taken to see that the chimney has a good draught. There should be sufficient height between the top of the furnace and the ceiling of the cellar to permit a good rise for all the hot-air pipes from the furnace. If there is not sufficient height in the collar to admit of this, the furnace should be set into a pit dug out below the cellar floor and bricked up. Ample room should be allowed in front of the furnace for cleaning

out ashes. All the pipes should be kept as close to the furnace as possible. If any hot-air pipe is extended more than fifteen feet from it, it should be encased with about half an inch space around, with both ends of casing entirely closed, to prevent the loss of heat. The location of the furnace should be so that the length of hot-air pipes shall be about equal. The smoke-pipe should be run directly to the chimney. Dampers should be placed in all the hot-air pipes close to the furnace, and, when the pipes are not in use, the dampers should be closed. The vapor-pan should be placed where the water will not boil. In some cases, if set on the top of the furnace, the water will boil over and crack the furnace. A proper place must be provided for it. In a brick-set furnace, the vapor-pan should be automatic in action, being connected with an outside pan with a ball and cock. Without this arrangement it is hard to keep up a regular supply of vapor, as this is a point generally neglected.

In order to distribute the heat through the rooms, the ventilating registers must be located in the proper places. They should be placed in the floor near the windows or in the coldest part of each room, so as to draw the heat to that part. Never run a hot-air pipe up an outside wall if you wish success with your work. If ventilators are put into a side wall, be sure that they extend down entirely to the floor, otherwise there will be a cold stratum of air next the floor, causing cold feet. A failure to do this, causes children to have cold feet at school. People frequently suffer in a similar way at church.

LIQUID AIR, THE COMING FORCE.

Water freezes at 32° above zero. Mercury in a thermometer freezes solid at 40-42° below zero. The alcohol in a spirit thermometer freezes at 200° below. Air becomes liquid at 312° below zero.

Eight hundred cubic feet of free air are condensed into one cubic foot of liquid air. One pint weighs one pound, like water.

By the aid of a 50-horse power steam air-pump, ordinary air is compressed until it becomes red hot. Then it is cooled in submerged pipes, and is further compressed until the pressure is registered at thousands of pounds to the square inch. More cooling is done. more pressure applied, until finally the air liquifies. It oozes through the steel of

the pipe in the shape of a milky white vapor and trickles down into the receptacle below.

As there is a difference of 344° between the temperatures of ice and liquid air, it will be understood why liquid air boils furiously even when placed on a block of ice.

A hand thrust in this liquid, in appearance like water, would be destroyed in 10 seconds, but if drawn out instantly, the moisture of the skin freezing to ice would be protection enough. The feeling at touching the liquid is like that of iron at white heat.

Like quicksilver, liquid air does not adhere. If poured over silk, it will leave no stain.

When boiling, the vapor of liquid air, being nothing but highly-compressed air, sinks to the ground.

If water is poured into liquid air it turns to ice instantly, and of such a low temperature that it will not melt near a red-hot stove for a long time.

A stick of arc light carbon, heated to 2,000 degrees above zero, thrust into liquid air, causes the oxygen in it to burn with a dazzling bright flame.

A teaspoonful of liquid air in a close vessel, if lighted, explodes with tremendous force, jarring the ground like an earthquake.

The expansive power of liquid air is about 20 times greater than that of steam.

Ten years ago it cost about $2,000 to produce a gallon of liquid air. To-day, so Prof. Chas. E. Tripler, of New York, states, it can be manufactured at a cost of 3 or 4 cents per gallon, at the rate of 40 or 50 gallons a day.

A steam engine horse-power is now figured at $36.00 a year expense; by the use of liquid air it should not be more than $7.00.

A pocket flask full of liquid air will furnish free air for a submarine apparatus for hours.

EXPLOSION OF A DOMESTIC HOT WATER BOILER.

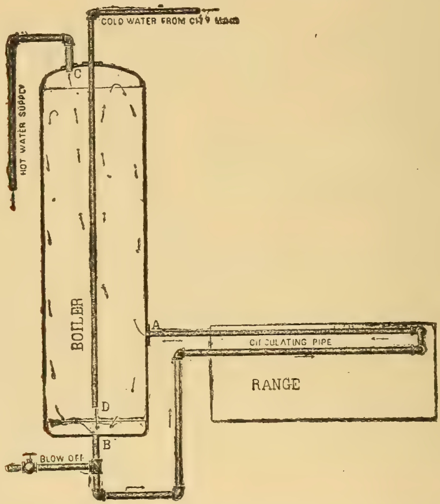
Explosions of domestic hot water boilers attached to cooking ranges, water-backs in ranges, etc., through freezing up of the pipes in cold weather, are becoming so frequent that it may not be out of place to give an account of one of the most destructive ones that has occurred recently, and point out its cause.

The boiler in question was used in an hotel in a large city

in one of the Northwestern States, where the temperature is very low at times. It was connected to the kitchen range, the range was a very large one, and the heating surface was furnished by a coil of 1½ inch pipe, placed near the top, instead of the cast-iron front or back, such as is commonly used in the smaller ranges in private dwellings. The connections to the boiler were made in the usual manner; the accompanying cut shows its essential features.

The operation of all boilers of this sort is as follows:

The connections being made, as shown in cut, the water is turned on from the main supply, and the entire system is



filled with water. When it is filled, and all outlets are closed, it is evident that no more water can run in, although the boiler is in free connection with, and is subjected to, the full pressure of the source of supply. When a fire is started in the range, and the water in the circulating pipes, or water-back, is heated, the water expands, is consequently lighter, and flows out through the pipe into the boiler at A, as this connection is placed higher up than the one at B; this starts the circulation, and the water, as it becomes

heated, constantly flows into the boiler at A, and rises to the upper part of the boiler, while the cooler water at the bottom of the boiler flows out into the circulating pipes at B, and, if no water is drawn, a slow circulation goes on, as heat is radiated from the boiler, in the direction indicated by the arrows, the water at the top of the boiler always being much hotter than at the bottom. When the hot cock is opened, cold water instantly begins to flow into the boiler at D, by reason of the pressure on the city main, and forces hot water out of the boiler at C. Thus it will be seen that hot water cannot be drawn unless the cold water inlet is free, and it is equally evident that cold water cannot enter the boiler unless the hot water cock or some other outlet is open.

The above points being understood, we are in a position to investigate the cause of the explosion referred to, which killed one person and badly injured twelve or thirteen others, besides badly damaging the building.

On the morning of the explosion fire was started as usual in the range about four o'clock a. m- It was found, on trying to draw water, that none could be had from either cold or hot water pipes; it was rightly judged that the pipes were frozen. The fire was continued in the range, however, and the breakfast prepared as best it could be, and a plumber sent for to thaw out the pipes. He arrived on the premises about seven o'clock, as would naturally be the case. He opened both hot and cold water cocks, and, getting neither steam nor water, concluded there was no danger, and proceeded to thaw out some pipes in the laundry department first. About an hour afterward the explosion occurred. The lower head of the boiler let go, and the main portion of the boiler shot upward like a rocket through the four stories of the hotel and out through the roof.

The coroner held an inquest on the remains of the person killed, and some of the testimony given, as reported in a local paper, would be amusing were it not for the tragic nature of the affair which called it out. The usual expert, with the usual vast and unlimited years of experience, was there, and swore positively to statements which a ten-year-old boy who had been a week in the business ought to be ashamed to make. He had examined the wreck with a view to solving the mystery (?) The matter was as much of a mystery now as on the day of the explosion. His theories were exploded as fast as he presented them. The boiler must have been empty. If it had been full of water, it could not possibly have exploded, etc., etc. And then a lot more nonsense about the "peculiar" construction of the boiler

As a matter of fact, there was nothing peculiar about the boiler or its connections. Everything was precisely like all boilers of its class, of which there are probably hundreds of thousands in daily operation throughout the country, and, moreover, they were all right.

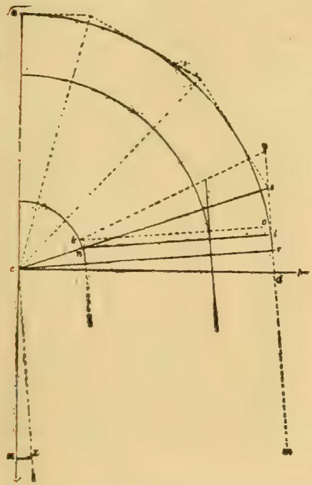
Now let us inquire what caused the explosion. Everything was all right at eight o'clock the previous evening, for water was drawn at that time. The fire was built in the range at four o'clock a. m. It is admitted that the cold water supply pipes were frozen, for no water could be had for kitchen use. It is also proved absolutely that the hot water supply was frozen or otherwise stopped up, by the fact that at seven o'clock the plumber who came to thaw out the pipes opened the hot water cock and got "neither water nor steam." Here was his opportunity to prevent any trouble, but he let it pass. Any one who understood his business would have known that there must have been a tremendous pressure in the boiler at this time, as the range had been fired steadily for three hours; there were about eight square feet heating surface exposed to the fire by the circulating pipe in the range, and there had been no outlet for the great pressure which must have been generated during this three hours firing. The blow-off cock should have been tried at once; if this were clear, and the probability is, from its proximity to the range, that it was clear, the pressure could have been relieved, and disaster averted. If the blow-off proved to be stopped up, then the fire should have been at once taken out of the range. At the time the plumber opened the cocks connecting with the boiler, it probably was under a pressure of 400 or 500 pounds per square inch. An ordinary cast-iron waterback such as is used in small ranges in private houses would have exploded shortly after the fire was built, but it will be noticed that the heating surface in this case was furnished by a coil of 1½-inch pipe; this was very strong, and the boiler was the first thing to give way, simply because it was the weakest part of the system.

Accidents of this sort can be easily avoided by exercising a little intelligence and care. The hot water cock should always be opened the first thing on entering the kitchen every morning. If the water flows freely, fire may then be started in the range without danger. If it does not flow freely, don't build a fire until it does.

A Cement to Make Joints for Granite Monuments—Use clean sand, twenty parts; litharge, two parts; quicklime one part, and linseed oil to form a thin paste.

USEFUL SHOP KINKS.

Fig. 1. A rule for different angles, or rise of elevations for elbows:



The usual rise given to furnace pipe elbows is one inch to the foot. A rule to obtain the desired result is as follows, and is almost identical with the one commonly used to get the height and pitch of miter line of right-angled elbows. It is applicable to any sized throat and any sized elbow; also, to elbows with any number of pieces or sections.

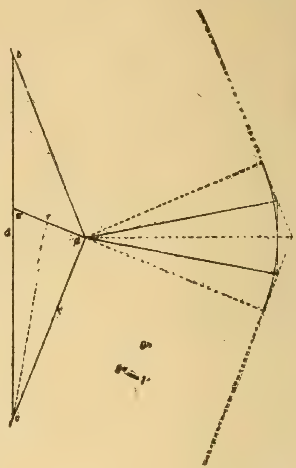
First draw lines *a c* and *c b*, Fig. 1, at right angles to each other. From point *c* on line *c b*, measure off 1 foot, and perpendicular from the point thus obtained erect line *d* to *r*, which is the desired height you wish the elbow to rise, or angle from a true right-angled elbow, in this case one inch to the foot. From point *c* as center, draw the arc *a* to *r*. From point *r* draw the line *r c* for base line. This will give the correct elevation, as proof clearly shows by the dotted lines *c* to *z* and *r* to *m;* these show the continuation that the elbow leads to, namely, as in this instance, 1 inch to the foot, or 1 foot in 12 feet. The line *c* to *x* is 1 foot, and from *x* to *z*, 1 inch.

If an elbow of four pieces is desired, divide the arc or curve *r* to *a* into six equal parts; if an elbow of three pieces or sections is wanted, divide same into four equal parts. From point *c* for a four-piece elbow, draw line *c* to *s*, and from point *n*, where inner curve of elbow intersects line *c s*, draw line *n* to *l* parallel to line *c r*, and same intersecting line *r s* at *l*. This much gives the pitch and rise for miter line for a four-piece elbow of the desired elevation. For a three-piece elbow the dotted lines from point *k* on the inner

curve to points *u* and *o* on outer curve, give the miter desired.

I have also shown a smaller-sized elbow in the drawing to show how the rule works, and is applied on same. It is, of course, not necessary to give the same size of throat, as is given in the drawing, nor the same outside sweep. This rule will suit any case or sized elbow as may be desired, and as one becomes familiar with the working of the rule, some of the other lines need not be drawn out, but are here given to make the drawing complete.

FIG. 3.



The above is given to get the complete data for side elevation which are necessary to develop the patterns for the different sections of an elbow. To develop the same I will give a quick snap rule, which comes so near right as to be practically almost correct. I will, however, first give a good snap rule for angles.

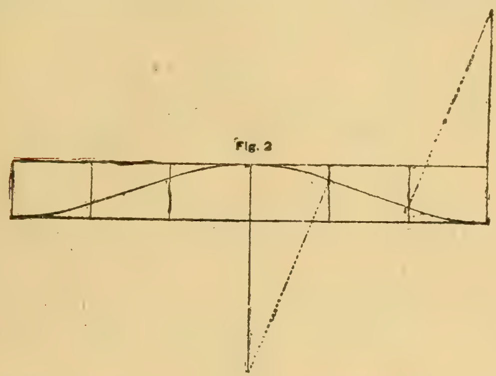
If Fig. 3 is examined, it shows the usual long and tedious geometrical method of obtaining miter lines for both a two-piece, and also a three-piece angle, both of the angles being of the same pitch. The solid lines are for a three-piece angle, and the dotted lines are for a two-piece angle.

Now, to do away with all this drawing, and to get a quick and very nearly correct method to obtain the desired result, suppose an angle is wanted as is given by the lines *a b* and *a* to *c*, Fig. 3, the diameter to be as full drawing requires, proceed as follows: First measure off the distance which is the size of diameter wanted, from *a* to *b*; do the same from *a* to *c*, and from points thus obtained, which are *c* and *b*, draw the line *d* from *c* to *b*. Then from either line, *a c* or line *a b*, draw at right angles the line *a* to *x*, as shown, the line *a x* intersecting line *d* at *x*. This much gives the required elevation for miter line of a two-piece angle as called

for; line *d* from *c* to *x* is miter line, *a* to *x* is height of rise, and *a* to *c*, base line, which is size of diameter called for. The line *x* to *a* divided into half gives the point *r* where the miter line intersects., of a three-piece angle ; *r* to *a* is height, *a* to *c* is base line, and *c* to *r* is miter line, as will be seen by dotted line in drawing. Twice the length of distance of line from points *a* to is the width of outer curve of center section. You must, of course, allow for laps or burrs for joining same together when cutting pattern.

Compare this with the solid line center section of full side elevation, and see how much quicker this method is over the old way. When once accustomed to use this method, you will use no other. This rule is absolutely correct for a two piece angle, and varies so little on a three-piece angle from

Fig. 2



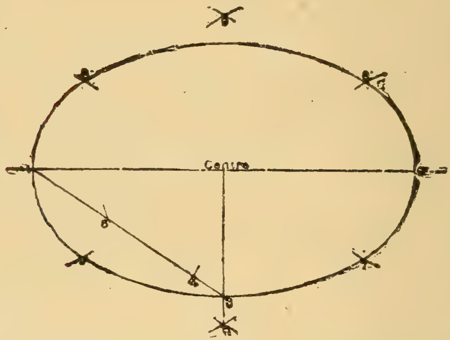
being absolutely correct, as that the variation is practically of no moment.

To develop the stretch-out, Fig. 2, lay out the full length of circumference, as is shown in Fig. 2 from *a* to *b*, and divide this length into six equal parts as in drawing. Make the center line, No. 2, same height as required, as in this case for the two-piece angle of Fig. 3. Next divide the right and left lines nearest to the center line, into four equal parts, and mark of one off these parts nearest to the top of each line ; and do the same as to spacing to the lines nearest to the end of stretch-out, as lines No. 4 and *r*, but with the difference that you mark off one space at the bottom of each line as the drawing fully shows. Continue the center line

indefinitely downward, and with dividers strike the arc 1, 2 and 3, cutting lines at points 1, 2 and 3. Draw line *b* indefinitely upward, reverse the dividers, and with line *b* as center line, draw the arc from point 5 to point 4, cutting points 5 and 4; do the same on the other end. Then draw a straight line from point 3 to 4, and same from 1 to *r*. This completes the pattern. Allow for locks or laps on both ends, and miter lines, of course.

The method given above is an old one, but not so universally known among tinners as its merits deserve. This method is also applicable to develop the pattern for elbow as given in Fig. 1. I use it for all kinds of elbows.

TO DRAW ANY OVAL WITH SQUARE AND CIRCLE.



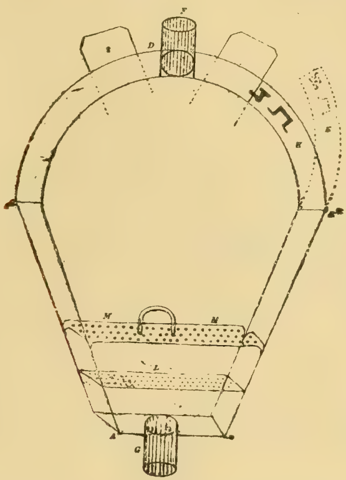
The following is a correct rule to draw any size or oval used in the tin shop, with square and circle:

Draw the line from 1 to 2, which is the length of the oval. Draw line from center to 3, which is one-half the width, and draw a line from 1 to 3. Set compass from 1 to center; leave one point on 1, and mark 4. Set compass from center to 3. Leave one end (of compass) in center and mark 5. Set compass from 4 to 5, and from 6 draw head lines of circles 7 and 8, and dot 7 and 8 from points 1 and 2. Set compass from 7 to 7, and mark 9 from 7 7 and 8 8. Complete oval from 9.

RAIN WATER STRAINER.

I hand you a sketch of a rain water strainer which I have put up and which gives good results. It is eighteen inches high, twelve inches in diameter at the half-circle, five and a half inches length of bottom, and five inches deep. Allow for all seams.

A, A^2, D, B^2, B, represents the outside of finished

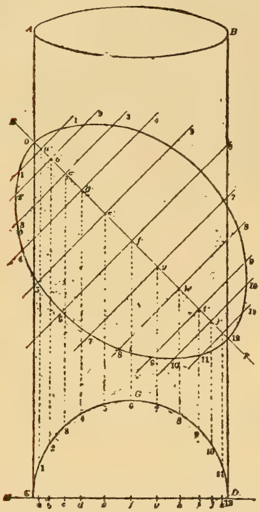


strainer. K is a section of circular top hinged at B^2 and fastened with a turn button. The dotted lines at E show the section of circular top, K, partly open; m is a galvanized strainer with three-eighth inch holes. The strainer rests upon supports at the ends, and may be removed at will. L is a tin strainer with one-eighth inch holes, and is soldered in place. F and G are three-inch inlet and outlet. 2 2 are straps on back side, by which the strainer is fastened to the building.

As will be seen, the top strainer catches the refuse which is washed from the roof and gutters, and is easily taken out; the finer particles are caught below and may be removed when the top strainer is out.

OVAL DAMPER.

Inclosed please find method of obtaining an oval damper, that when closed in, the pipe will be at an angle of 45°.



Let A B C D represent the pipe, and E F the line through the pipe at an angle of 45°, which will be the position of the damper when closed. Divide the semi-circle into any even number of equal parts, as, 1, 2, 3, 4, etc. (even numbers, because in doing so you obtain the center line of the short diameter of the damper). Carry lines up until they cut the line E F as dotted lines, then draw solid lines across, and at right angles to the line E F, and number them to correspond with spaces in semi-circle, as 1, 2, 3, 4, etc. With the dividers step from a to 1 on dotted line, and with one point of the dividers at a′; cut the solid line 1 each side of the line E. F. Step from b to 2, and with one point of the dividers on b′, cut the solid line to both sides of the line E F, and so on until all the spaces have been transferred. Now set the dividers so as to draw an arc through the points 5, 6, 7, both sides of the line E F, and then set them to draw the two end circles, as 11, 12, 11, and 1, 0, 1. Draw a′ line free hand through the points from 1 to 5, and from 7 to 11, both sides of line E F, and you have the required damper.

The same method is used to obtain the shape of a hole in piece of sheet metal that a pipe is to pass through on an angle. For instance, let A B C D represent a pipe, and E F a roof through which the pipe passes; we want a piece of iron or tin laid on the roof for the pipe to pass through; we want to know how to get the shape of the opening. Employ this method and it will give you the required article every time.

A TAPERING ROUND-CORNERED SQUARE RESERVOIR.

Not long since, there was an inquiry in your columns for a pattern for a tapering, round-cornered square reservoir. I give herewith diagrams for constructing such a pattern:

Fig. 1 is the size, top and bottom (A C F H D B G E is the top, and I K N P L J O M is the bottom), and Fig. 1 the upright height. Take the perpendicular height a d, Fig. 1, and mark it off from h to k, Fig. 3. Take the radius for the corners d C, Fig. 1, and mark it off from h to i, Fig. 3, also the radius dK; mark off from K to l, drawing a line from i l to cut the line h K, which gives the slanting height and the radius required for striking the corners. Draw the lines I K and A C, Fig. 4, the same length as I K, Fig. 2, and the same distance apart as l to i, Fig. 3; prolong the lines A I and C K, Fig. 4, till A c and C d equals to i m, Fig. 3. With radius d C, Fig. 4, using d and c as centers, strike the curves C F and A E, and, with a radius d K, Fig. 4, using the same centers, strike the curves K N and I M. Take the length of the large quar-

1

2

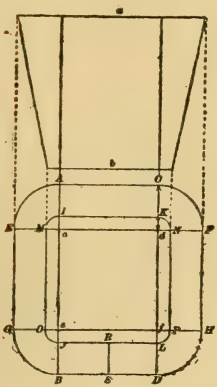
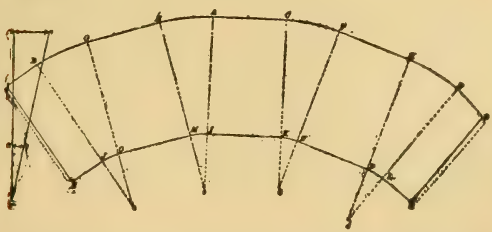


Fig. 3. Fig. 4.



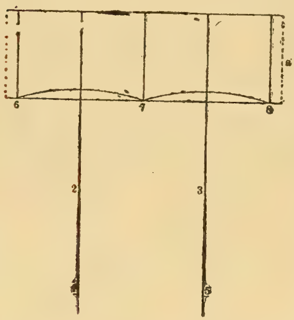
ter-circle D H, Fig. 2, and dot off the same distance from C to F, Fig. 4; make A E equal to C F. and draw

lines from E and F to the centers c and d; draw E G and M O at right angles with E c. Take the distance from A to C, and make the same distance from E to G and M to O, Fig. 3. Draw G e parallel to E c. From G mark off point e, the same length as E to c, then, using e as center, strike the curves G B and O J, making the curve G B equal to A E; draw line from B to center c, draw B T and J R at right angles to B e, taking the distance from B to S, Fig. 2, mark off the same distance from B to S and J to R, draw S R parallel with B e, and proceed in the same manner with the other end; adding on the laps, as shown, will make the pattern complete in one piece, being joined together at R S.

PATTERN FOR T JOINTS.

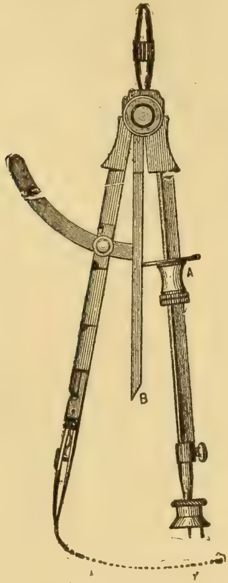
The following rule is a short and explicit method of obtaining a pattern for T joints where different diameters are required. Suppose, for instance, a T is required whose diameters are 3 and 8 inches respectively.

Divide the stretch-out, *a a* (which must be the exact length required to form up 3 inches, allowing for locks as shown by dotted lines) in center as shown in the figure. Then divide each half equally between 6-7 and 7-8 as shown by indefinite lines 2 and 3. Now spread the compass to 8 inches, which is the diameter of the large pipe, set one point at 4, and the other at 6; strike a circle to 7; then set compass on the other line at 5 and draw circle 7 to 8. Cut out the circles, and you have your pattern. The same rule applies to any diameter by spreading compass to the larger diameter and striking the circle on the stretch-out required for smaller diameter as shown above.

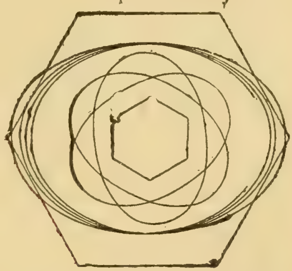


Ireland has seventy-six collieries — nine in Ulster, seven in Connaught, thirty-one in Leinster, and twenty-nine in Munster. Very few of these are being worked.

NOVEL DRAWING INSTRUMENT.



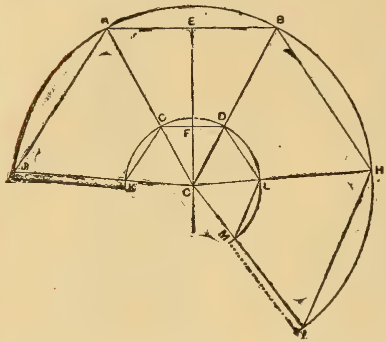
A pair of dividers, or compasses, which will describe any figure is shown herewith. It is of English origin and very simple. The former, or template A, is affixed to one leg, and beats against the mid-leg B, around which, of course, revolves the working leg. By this means the drawing pen or pencil is moved in and out in an obvious manner. Specimens of the work are shown in Fig. 2.



The quality of wood is determined by the number of spirals. The best has about thirty " crinkles " in an inch.

TO DESCRIBE A PATTERN FOR A TAPERING SQUARE ARTICLE.

Erect the perpendicular line G E; draw the line A B



at right angle to G E; make E F equal to the slant height, and draw the line C D parallel to A B; make A B equal in length to one side of the base; make C D equal in length to one side of the top or smallest end, draw the lines A G and B G, cutting the points A C and B D, G as a center with the radii G C and G A. Describe the arcs K M and J I; set off on the arc J I, J A, B H and H I equal in length to A B, and draw the lines J G, H G, and I G, also the lines J A, B H, H I, and K C, D L, L M.

Edges to be allowed.

THE PAINTING OF IRON.

Cast and wrought iron behave very differently under atmospheric influences, and require somewhat different treatment. The decay of iron becomes very marked in certain situations, and weakens the metal in direct proportion to the depth to which it has penetrated, and, although where the metal is in a quantity this is not appreciable, it really becomes so when the metal is under three-fourths of an inch in thickness. The natural surface of cast iron is very much harder than the interior, occasioned by its becoming chilled, or by its containing a large quantity of silica, and affords an excellent natural protection, but, should this surface be broken, rust attacks the metal and soon destroys it. It is very desirable that the casting be protected as soon after it leaves the mold as possible, and a priming coat of paint should be applied for this purpose; the other coats thought requisite can be given at leisure. In considering the painting of wrought iron, it must be noticed that, when iron is oxidized by contact with the atmosphere, two or three distinct layers

of scale form on the surface, which, unlike the skin upon cast iron, can be readily detached by bending or hammering the metal. It will be seen that the iron has a tendency to rust from the moment it leaves the hammer or rolls, and the scale above described must come away. One of the plans to preserve iron has been to coat it with paint when still hot at the mill, and, although this answers for a while, it is a very troublesome method, which iron masters cannot be persuaded to adopt, and the subsequent cutting processes to which it is submitted leave many parts of the iron bare. Besides, a good deal of the scale remains, and, until this has fallen off or been removed, any painting over it will be of little value. The only effectual way of protecting wrought iron is to effect a thorough and chemical cleansing of the surface of the metal upon which the paint is to be applied; that is, it must be immersed for three or four hours in water containing from one to two per cent. of sulphuric acid. The metal is afterward rinsed in cold water, and, if necessary, scoured with sand, put again into the pickle, and then well rinsed. If it is desired to keep iron already cleansed for a short time before painting, it is necessary to preserve it in a bath rendered alkaline by caustic lime, potash, soda, or their carbonates. Treatment with caustic lime water is, however, the cheapest and most easy method, and iron which has remained in it some hours will not rust by a slight exposure to dampness. Having obtained a clean surface, the question arises, what paint should be used upon iron? Bituminous paints, as well as those containing variable quantities of lard, were formerly considered solely available, but their failure was made apparent when the structure to which they were applied happened to be of magnitude, subjected to great inclemency of weather or to constant vibration. Recourse has, therefore, been had to iron oxide itself, and with satisfactory results. A pound of iron oxide paint, when mixed ready for use in the proportion of two-thirds oxide to one-third linseed oil, with careful work, should cover twenty-one square yards of sheet-iron, which is more than is obtained with lead compound.

INVENTOR OF THE SCREW-AUGER.

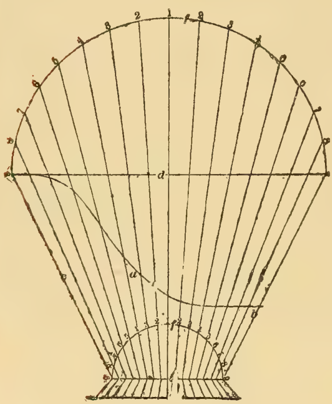
The screw-auger was invented by Thomas Garrett about 100 years ago. He lived near Oxford, Chester County, Pa. The single screw-auger was invented by a Philadelphian, and it is said to be the only one used with any satisfaction in very hard woods, where the double screw-augers become clogged.

RUST PROOF WRAPPING PAPER.

This is made by sifting on the sheet of pulp, in process of manufacture, a metallic zinc powder (blue powder), about to the extent of the weight of the dried paper, the pulp sheet is afterward pressed and dried by running through the rolls and over the drying cylinders as usual. The zinc powder adheres to the paper, and is partly incorporated with it, the amount varying with the thickness and wetness of the pulp sheet. The paper may be sized with glue or starch and then dusted with the zinc powder, or the powder may be stirred into the size and then applied to the surface of the paper. If silver, brass or iron articles are wrapped in paper thus prepared, the affinity of the zinc for the sulphureted hydrogen (always present in the air), chlorine or acid vapors, will prevent those substances from attacking the articles inclosed in the paper.

HIP-BATH IN TWO PIECES.

Fig. 1.

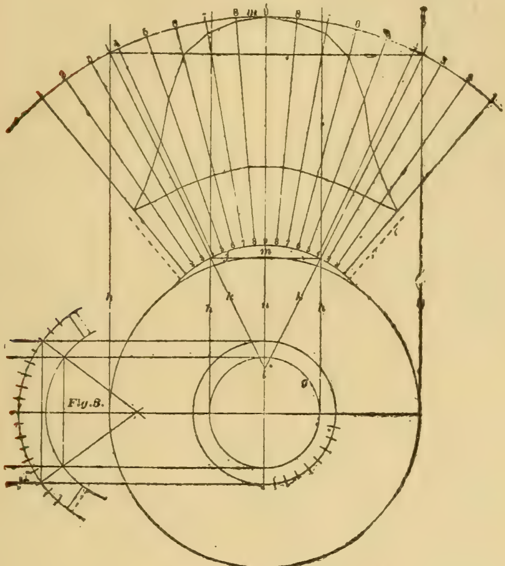


Draw the hip-bath full size, as it would look when finished, as in Fig. 1. Extend line *b*, or the front, to same height as *c*, the highest part of the tub. Draw line *d* parallel with *e*, or bottom of tub, until it intersects *c* and *b*. Strike the half-circle *f f*, and divide into any number of equal parts, as 1, 2, 3, 4, etc. (the more lines the better). For the points draw lines as shown in profile.

Set dividers same as when the circles in Fig. 1 were described, and strike the circles *g g*, and with a T square draw the perpendicular lines *h h h h*. Draw the line *i* parallel with the lines *h*. Take the height same as from *d* to *e*, in Fig. 1, and mark the line *j*, Fig. 1. Draw lines *k k* until they intersect at *l*. Set dividers at *l*, and strike the

circles *m m*. Draw line *n*, and, taking it as the center line, step each way one-fourth of the circumference, in as many parts as in profile, 1, 2, 3, 4, etc., and draw lines same as in Fig. 1.

Fig. 2.



Take a pair of dividers, and from the bottom of tub in profile step on the lines, as from 9 to 9, 8 to 8, etc., making the line in Fig. 2 equal to the lines in profile, stopping where the curved line *a* crosses. A line traced through the dots will give the pattern, is the foot, which is drawn the same as the other, with the exception of drawing the lines through.

A VERY durable black paint for out-of-door work, and for many other purposes, is made by grinding powdered charcoal in linseed oil, with sufficient litharge or drier. Thin for use with boiled linseed oil.

ROPE TRANSMISSION IN ENGLAND.

According to the London *Engineer*, a fly-rope apparently was first used in England in 1863, by Mr. Ramsbottom, for driving cranes at Crewe. These ropes were ⅝ inch in diameter when new, of cotton, and weighing 1½ ounces per foot. They lasted about eight months, and ran at 5,000 per minute. The total lengths of the rope were 800 feet, 320 feet and 560 feet. The grooves in the pulley were V-shaped, at an angle of 30°. The cord was supported every 12 feet or 14 feet by flat pieces of chilled cast iron. The actual power strain on the rope was about 17 pounds, and the ropes were kept tight by a pull of 109 pounds put on by a jockey pulley. Rope-gearing is now superseding belting and gearing in cotton mills. It has long been used in South Wales for driving helve hammers in tin-plate mills. The ropes are usually about 5¼ inches to 6¼ inches in circumference, of hemp. The diameter of the pulleys should be at least 30 times that of the rope, and the shafts should not be less than 20 feet apart. A 6½-inch rope is about equivalent to a leather belt 4 inches wide, running at the same speed—3,000 feet per minute. Such a rope will transmit 25 horse-power. The coefficient of resistance to slipping of a rope in a groove is about four times that of an equivalent belt.

HEAT-PROOF PAINTS.

Steam pipes, steam chests, boiler fronts, smoke connections and iron chimneys are often so highly heated that the paint upon them burns, changes color, blisters and often flakes off. After long protracted use, under varying circumstances, it has been found that a silica-graphite paint is well adapted to overcome these evils. Nothing but *boiled linseed oil* is required to thin the paint to the desired consistency for application, no dryer being necessary. This paint is applied in the usual manner with an ordinary brush. The color, of course, is black. But another paint, which admits of some variety in color, is mixed by making soapstone, in a state of fine powder, with a quick drying varnish of great tenacity and hardness. This will give the painted object a seemingly enameled surface, which is durable, and not affected by heat, acids, or the action of the atmosphere. When applied to wood it prevents rotting, and it arrests disintegration when applied to stone. It is well known that the inside of an iron ship is much more severely affected by corrosion than the outside, and this paint has proven itself to be a most efficient protection from inside corrosion. It is light, of fine grain,

can be tinted with suitable pigments, spreads easily, and takes hold of the fiber of the iron or steel quickly and tenaciously.

A cheap and effective battery can be made by dissolving common soap in boiling water and adding to it small amounts of bran and caustic potash or soda. This mixture, while warm, is poured in a jar containing a large carbon pole and an amalgamated zinc rod. When cold the battery "sets" after the manner of a jelly, and consequently will not readily evaporate or spill over.

NEW PROCESS FOR WIRE MANUFACTURE.

A machine for cheapening and improving steel or iron wire has been invented, which is calculated to make a change in many branches of industry in which iron, steel, copper and brass wire are used. The invention, which has just been patented, consists of a series of rolls in a continuous train, geared with a common driver, each pair of rolls having a greater speed than the pair preceding it, with an intervening friction clutch adapted to graduate the speed of the rolls to the speed of the wire in process of rolling. The entire process of manufacturing the smallest-sized wires from rods of one-half inch is done cold. The new process obviates the danger of unequal annealing, and of burning in the furnaces, and the wire is claimed to be more flexible and homogeneous than that produced by the common processes, and capable of sustaining greater longitudinal strain. It is, therefore, specially adapted for screws, nails, cables, pianofortes, and many other uses, and copper wire made by this process is claimed to be possessed of greatly increased electrical conductivity.

SLEEPERS USED BY THE WORLD'S RAILROADS.

According to the *Moniteur Industriel*, the six principal railways of France use more than 10,000 wooden sleepers per day, or 3,650,000 per annum. As a tree of ordinary dimensions will only yield ten sleepers, it will be necessary to cut down 1,000 trees per day. In the United States the consumption is much greater, amounting to about 15,000,000 sleepers per year, which is equivalent to the destruction of 170,000 acres of forest. The annual consumption of sleepers by the railways of the world is estimated at 40,000,000. From these figures the rapid progress of disforestation will be understood, and it is certain that the natural growth cannot keep pace with it.

WEIGHTS OF CAST IRON PIPES.

Weights, per foot, of Cast Iron Pipes in general use, including Socket and Spigot ends.

Diameter.	Thickness.	Weight per foot.	Diameter.	Thickness.	Weight per foot.
2 inches.	¼+ inch.	6¼ lbs.	14 inches	⅞ inch.	138 lbs.
2 "	⅜ "	9¼ "	16 "	½ "	85 "
3 "	½ "	14 "	16 "	⅝ "	108 "
3 "	¼+ "	11 "	16 "	¾ "	129 "
3 "	⅜ "	13½ "	16 "	⅞ "	152 "
3 "	½ "	18 "	16 "	1 "	175 "
3 "	⅝ "	23 "	18 "	⅝ "	114 "
4 "	⅜+ "	16½ "	18 "	¾ "	137 "
4 "	½ "	23 "	18 "	⅞ "	161 "
4 "	⅝ "	31 "	20 "	⅝ "	132 "
6 "	⅜ "	25 "	20 "	¾ "	160 "
6 "	½ "	33 "	20 "	⅞ "	197 "
6 "	⅝ "	42½ "	20 "	1 "	215 "
6 "	¾ "	52 "	24 "	⅝ "	159 "
8 "	⅜ "	40 "	24 "	¾ "	190 "
8 "	½ "	43½ "	24 "	⅞ "	224 "
8 "	⅝ "	56 "	24 "	1 "	257 "
8 "	¾ "	68 "	30 "	¾ "	237 "
10 "	$\frac{7}{16}$+ "	50 "	30 "	⅞ "	277 "
10 "	½ "	54 "	30 "	1 "	319 "
10 "	⅝ "	68 "	30 "	1⅛ "	360 "
10 "	¾ "	80 "	36 "	⅞ "	332 "
12 "	½ "	67 "	36 "	1 "	381 "
12 "	⅝ "	82 "	36 "	1⅛ "	429 "
12 "	¾ "	99 "	36 "	1¼ "	479 "
12 "	⅞ "	117 "	48 "	1 "	512 "
14 "	½ "	74 "	48 "	1⅛ "	584 "
"	⅝ "	94 "	48 "	1¼ "	685 "
"	¾ "	113 "	48 "	1½ "	775 "

POINTS FOR BUILDERS.

BY STEEL SQUARE.

Never compete with a "botch" if you know he is favored by the person about to build. He will undercut and beat you every time.

Favor the man who employs an architect. Under an honest architect you will have less friction, make more money, be better satisfied with your work, and give greater satisfaction to the owner than in working from plans furnished by a nondescript.

In tearing down old work, be as careful as putting up new.

Old material should never be destroyed simply because it is old.

When putting away old stuff, see that it is protected from rain and the atmosphere.

It costs about fifteen per cent. extra to work up old material, and this fact should be borne in mind, as I have known several contractors who paid dearly for their "whistle" in estimating on working up second-hand material.

These remarks apply to woodwork only. In using old brick, stone, slate and other miscellaneous materials, it is as well to add double price for working up.

Workmen do not care to handle old material, and justly so. It is ruinous to tools, painful to handle, and very destructive to clothing.

In my experience I always found it pay to advance the wages of workmen — skilled mechanics — while working up old material. This encouraged the men and spurred them to better efforts.

Sash frames, with sash weights, locks and trim complete, may be taken out of old buildings that are being taken down and preserved just as good as new by screwing slats and braces on them, which not only keep the frame square, but prevent the glass from being broken.

Doors, frames and trims may also be kept in good order until used, by taking the same precautions as in window frames.

Old scantlings and joists should have all nails drawn or hammered in before piling away.

Counters, shelving, draws and other store-fittings should be

kindly dealt with. They will all be called for sooner or later.

Take care of the locks, hinges, bolts, keys, and other hardware. Each individual piece represents money in a greater or less sum.

Old flooring can seldom be utilized, though I have seen it used for temporary purposes, such as fencing, covering of veranda floors, while finishing work on plastering, etc. As a rule, however, it does not pay to take it up carefully and preserve it.

Conductor pipes, metallic cornices, and sheet metal work generally can seldom be made available a second time, though all is worth caring for, as some parties may use it in repairs.

Sinks, wash-basins, bath-tubs, traps, heating appliances, grates, mantels and hearth-stones should be moved with care. They are always worth money and may be used in many places as substitutes for more inferior fixings.

Marble mantels require the most careful handling.

Perhaps the most difficult fixtures about a house to adapt a second time are the stairs. Yet, I have known where a shrewd contractor has so managed to put up new buildings that the old stairs taken from another building just suited. This may have been a "favorable accident," but the initiated reader will understand him. Seldom such accidents can occur.

Rails, balusters and newels may be utilized much readier than stairs, as the rail may be lengthened or shortened to suit variable conditions.

Gas fixtures should be cared for and stowed away in some dry place. They can often be made available, and are easily renovated if soiled or tarnished.

It is not wise to employ men to take down buildings who who have no other qualities to recommend them than their strength. As a rule they are like bears—have more strength than knowledge, and the lack of the latter is often an expensive desideratum. Employ for taking down the work good, careful mechanics, and do not have the work "rushed through." Rushers of this sort are expensive.

Never send old material to a mill to be sawed or planed. No matter how carefully nails, pebbles and sand have been hunted for, the saw or planer knives will most assuredly find some you overlooked; then there will be trouble at the mill.

Have some mercy for the workman's tools. If it can be avoided, do not work up old stuff into fine work. If not

avoidable, pay the workman something extra because of injury to tools.

Don't grumble if you do not get as good results from the use of old material as from new. The workman has much to contend with while working up old, nail-speckled, sand-covered material.

RULES FOR ESTIMATING COST OF PLASTERING AND STUCCO WORK.

PLASTERING.

Plastering is always measured by the square yard for all plain work, and by the foot superficial for all cornices of plain members, and by foot lineal for enriched or carved moldings in cornices.

By plain work is meant straight surfaces (like ordinary walls and ceilings), without regard to the style or quantity of finish put upon the job. Any paneled work, whether on walls or ceilings, run with a mold, would be rated by the foot superficial.

Different methods of valuing plastering find favor in different portions of the country. The following general rules are believed to be equitable and just to all parties:

Rule 1.—Measure on walls and ceilings the surface actually plastered without deducting any grounds or any openings of less extent than seven superficial yards.

Rule 2.—Returns of chimney breasts, pilasters and all strips of plastering, less than 12 inches in width, measure as 12 inches wide; and where the plastering is finished down upon the wash-board, surbase or wainscoting, add 6 inches to height of wall.

Rule 3.—In closets, add one-half to the measurement; or, if shelves are put up before plastering, charge double measurement. Raking ceilings and soffits of stairs, add one-half to the measurement. Circular or elliptical work, charge two prices; domes or groined ceilings, three prices.

Rule 4.—For each 12 feet interior work is done further from the ground than the first 12 feet, add five per cent. For outside work, add one per cent. for each foot the work is done above the first 12 feet.

STUCCO WORK.

Rule 1.—All moldings, less than one foot girt, to be rated as one foot; over one foot, to be taken superficial. When work requires two molds to run same cornice, add one-fifth.

Rule 2.—For each internal angle or miter, add one foot to length of cornice; and each external angle add two feet. All small sections of cornice less than 12 inches long measure as 12 inches. For raking cornices add one-half. Circular or elliptical work, double price; domes and groins, three prices.

Rule 3.—For enrichments of all kinds, charge an agreed price.

Rule 4.—For each 12 feet above the first 12 feet from the ground, add five per cent.

CHINESE CASH.

A large number are engaged in molding, casting and finishing the "cash" used as coin all over China, Mexican dollars and Sycee silver being used in large transactions. The cash are made from an alloy of copper and zinc, nearly the same as the well-known Munn metal, and it takes about 1,000 of them to answer as change for a dollar, so minute and low do prices run in this country, of which I will only give one instance. The fare for crossing the ferry on the Peiho was only two cash, or one-fifth of a cent.

DEEP SOUNDINGS NEAR THE FRIENDLY ISLANDS.

Her Majesty's surveying ship Egeria, under the command of Captain P. Aldrich, R. N., has, during a long sounding cruise and search for reported banks to the south of the Friendly Islands, obtained two very deep soundings of 4,295 fathoms and 4,430 fathoms, equal to five English miles respectively, the latter in latitude 84 deg. 37 min. S., longitude 175 deg. 8 min. W., the other about twelve miles to the southward. These depths are more than 1,000 fathoms greater than any before obtained in the Southern Hemisphere, and are only surpassed, as far as is yet known, in three spots in the the world—one of 4,655 fathoms off the northeast coast of Japan, found by the United States steamship Tuscarora; one of 4,475 fathoms south of the Ladrone Islands by the Challenger; and one of 4,561 north of Porto Rico, by the United States ship Blake. Captain Aldrich's soundings were obtained with a Lucas sounding machine and galvanized wire. The deeper one occupied three hours, and was obtained in a considerably confused sea, a specimen of the bottom being successfully recovered. Temperature of the bottom, 33.7 deg. Fahr.

SIZE AND WEIGHT OF FLAT-TOP CANS.

The following table gives the size of the flat top cans and the amount of material required when galvanized iron is used in their construction. The table shows the net weight per can with iron from No. 27 gauge to No. 20 gauge. No allowance is made for seams, hoops, or solder.

SIZE CANS.			WEIGHT PER CAN.															
			No. 27 G.		No. 26 G.		No. 25 G.		No. 24 G.		No. 23 G.		No. 22 G.		No. 21 G.		No. 20 G.	
No. Gal.	Diam. Inches.	Height Inches.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.
1	6¾	6¾	1	6	1	7												
2	8½	8¾	2	2	2	4												
3	9	11½	2	13	3	0												
5	10½	13¾	3	13	4	2	4	6	4	14	5	7	5	15	6	9	7	6
5	11½	11½	3	13	4	2	4	6	4	14	5	7	5	15	6	9	7	6
6	11½	13½	4	3	4	8	4	12	5	6	5	15	6	9	7	2	8	1
8	13½	13½	5	4	5	10	6	0	6	12	7	8	8	9	9		10	1
10	13½	16½	6	0	6	7	6	14	7	12	8	9	9	7	10	5	11	9
15	15½	9	7	15	8	8	9	1	10	3	11	5	12	7	13	9	15	4
20	17½	19½	9	8	10	2	10	13	12	3	13	8	14	4	16	3	18	4
20	16	23.	9	8	10	2	10	13	12	3	13	8	14	4	16	3	18	4
25	18	23	11	0	11	12	12	8	14	1	15	11	17	4	18	13	21	2
30	18½	26½	12	10	13	8	14	7	16	4	18	0	19	13	21	10	23	11
35	18½	30½	14	0	15	0	16	0	18	0	20	0	22	0	24	0	27	0
40	18¾	34	15	9	16	10	17	11	19	15	22	2	24	6	26	9	29	14
45	19½	35	16	10	17	13	19	0	21	6	23	12	26	2	28	8	32	1
50	20½	35	17	11	18	15	20	3	22	12	25	4	27	13	30	5	34	2
55	21¼	36	18	14	20	6	21	10	24	3	26	7	29	12	32	7	36	8
60	22	37	20	3	21	10	23	0	25	15	28	12	31	10	34	8	38	13
65	22½	38	21	3	22	9	24	3	27	4	30	5	33	6	36	5	40	14
70	23	40	22	10	24	4	25	13	29	1	32	5	35	8	38	12	43	9
75	23½	40	23	3	24	14	26	9	29	13	33	2	36	7	39	13	44	13
80	24½	40	24	7	26	3	27	15	31	7	34	15	38	6	41	15	47	3
85	25	40	25	1	26	14	28	10	32	7	35	13	39	6	43	0	48	5
90	24½	45	26	13	28	11	30	10	34	7	38	4	42	1	45	15	51	11
95	25	45	27	7	29	6	31	5	35	4	39	3	43	1	47	0	52	14
100	26	45	28	13	30	14	32	14	37	0	41	2	45	4	49	6	55	9
125	27½	50	33	8	35	15	38	5	43	2	47	14	52	11	57	7	64	10
150	29	52½	37	1	39	12	42	6	47	11	52	15	58	4	63	9	71	9
175	30	57½	41	9	44	8	47	7	53	6	59	5	65	3	71	3	80	1
200	30¾	64	46	6	49	12	53	3	59	14	66	6	73	0	79	10	89	10

Mexican coal has been successfully used for making coke at Pittsburg.

WEIGHTS, &c., OF MATERIALS.

Specific Gravity — Weight and Strength of Metals.

METALS.	Specific Gravity.	Weight of 1 cubic foot.	Weight of 1 cubic inch.	Strength per sq. in.		
				Ten-sile.	Crush-ing.	Trans-verse.
		lbs.	lbs.	tons	tons	tons
Platinum...........	21.531	1343.9	.775	—	—	—
" sheet.....	23.0	1435.6	.828	—	—	—
Gold, pure..........	18.417	1150.0	.665	9.1	—	—
Mercury............	13.596	848.75	.49117	—	—	—
Silver...............	10.474	653.8	.377	18.2	—	—
Lead, cast..........	11.36	708.5	.408	.8	3.1	—
" sheet........	11.4	711.6	.41	1.5	—	—
Bismuth............	9.822	613.1	.353	1.45	—	—
Copper, bolts.......	8.85	552.4	.318	17.0	—	—
" cast........	8.607	537.3	.31	8.4	—	—
" sheet.......	8.78	548.1	.316	13.4	—	—
" wire.......	8.9	555.0	.32	26.0	—	—
Tin, cast............	7.291	455.1	.262	2.0	6.7	—
Zinc, cast...........	7.0	437.0	.252	3.3	—	—
Iron, cast, from....	7.0	437.0	.252	6.0	36.0	2.0
" " to.......	7.6	474.4	.273	13.0	64.0	3.4
" " , average.	7.3	451.0	.26	7.3	48.0	2.6
Iron, wrought, from	7.5	474.4	.273	16.0	16.0	3.0
" " to...	7.8	486.9	.281	29.0	18.0	5.5
" " average	7.78	485.6	.28	22.0	16.9	3.8
Iron Wire..........	—	—	—	40.0	—	—
Steel "	8.0	499.0	.288	52.0	150.0	—
" Plates.........	—	—	—	35.0	90.0	—
Antimony, cast....	6.72	419.5	.242	.47	—	—
Aluminum, sheet..	2.67	166.6	.096	—	—	—
" cast...	2.56	159.8	.092	—	—	—
Aluminum Bronze, 20 to 95 pr. ct. of copper............	7.68	478.4	.276	32.0	58.0	—
Gun-Metal, 10 copper, 1 tin.........	8.564	528.36	.306	16.1	—	—
Gun-Metal, 7 copper, 1 tin.........	8.456	527.89	.305	13.6	—	—
Brass, cast, 3 copper, 1 zinc..	8.397	524.18	.3	13.1	—	—
White Metal, (Babbitt's)............	7.31	456.32	.263	—	—	—

BENZINE.—Benzine gas is nearly three times as heavy as air. One cubic foot of benzine gas weighs 0.2181 lb.; while 1 lb of gas occupies at ordinary temperature and pressure 4.58 cubic feet. The corresponding figures for air being 0.08 lb. and 12.29 cubic feet respectively.

SPECIFIC GRAVITY AND STRENGTH OF TIMBER

Name.	Specific gravity.	Tenacity per square inch.	Crushing stress per square inch.
		lbs.	lbs.
Ebony	1.18	—	18,000
Greenheart	1.05	8,000	12,000
Teak	.98	15,000	12,000
Lancewood	.95	20,000	7,000
Oak, American	.93	14,500	7,700
" English	.93	15,000	8,250
Mahogany	.85	15,000	8,200
Hornbeam	.76	15.000	8,500
Ash	.75	17,700	9,000
Pitch-pine	.70	12,000	6,000
Beech	.68	17,000	8,500
Elm	.55	14,000	10,300
Red Pine	.54	10,500	5,000
Fir, Larch	.53	11,000	5,500
" Riga	.53	12.500	5,300

A VALUABLE POINT FOR PAPER-MAKERS.

Iron is apt to discolor paper by rusting after it has been abraded from the paper-making machinery. Magnetism has, therefore. been called in by a German manufacturer to clear away the iron specks. A series of magnets are arranged in the form of a comb and hung across the stream of pulp and water, which, in passing the magnetic teeth of the comb, delivers up the iron particles.

PRECAUTIONS TO BE TAKEN IN USING LIQUID FUEL IN FURNACES.

In lighting up from "all cold," it is as well to open the fire door and damper so as to create a draught, and thereby drive away any possible explosive mixture of air and oil gas which might be present through leaks in the oil valves. If possible, blow through with the steam jet from an adjacent boiler, then introduce the lighted torch, and *then (not before)* turn on the oil supply. If relighting a "hot" furnace. *i. e.*, that in which the oil has been shut off for a time, as, say, during a meal hour, blow through

thoroughly with steam first as a precaution, and proceed as before. The great danger to be guarded against is the formation of an explosive mixture in a very confined space. As a general rule, the lighted torch should be affixed to a bent rod, so that the attendant can stand away from the fire door. Remember that a *flame must never be brought to the oil, but the oil must always be brought to the flame, i. e.*, in oil fuel furnaces, there must first be a flame in the furnace, then the oil can be turned on.

Petroleum.—In carrying petroleum or its products on motor-vehicles, never allow the containing vessel to be quite full, as petroleum sensibly expands when heated, and unless provision is made for this, the tank might be ruptured.

USEFUL NUMBERS FOR WEIGHT OF IRON.

⅝ in. dia. = 1 lb. per ft. run.	1¼ in. dia. = 4 lbs. per ft. run.
⅞ in. dia. = 2 lbs. per ft. run.	1¾ in. dia. = 8 lbs. per ft. run.

1 in. sq. of iron weighs 10 lbs. per yard, or 3.33 lbs. per ft.
1 square foot of iron 1 inch thick weighs 40 lbs.
1 cubic inch of wrought iron weighs 0.28 lb.
1 cubic inch of cast iron weighs 0.26 lb.
400 cubic inches of wrought iron weigh 1 cwt.
425 cubic inches of cast iron weigh 1 cwt.

PAINTWORK.

It may be useful to know that a gallon of paint will cover from 450 to 630 superficial feet of wood. On a well-painted surface of iron the gallon will cover 720 feet. In estimating painting to old work, the first thing to do is to find out the nature of the surface, whether it is porous, rough or smooth, hard or soft. The surface of stucco, for example, will take a great deal more paint than on of wood, much depending on the circumstance whether it has been painted, and what state the surface is in. We have known prices tendered for outside painting that have been seriously wrong, owing to the want of knowing the condition of the stucco work. A correct estimate of repainting woodwork cannot be made from the quantities only; a personal examination ought to be made in every case where there is much work to be done. A great many painters trust to the quantity; the consequence is, nothing is allowed to remove old paint, or for scouring, and the stopping of cracks.

Then, there is painting and painting. It can be done well and artistically, or indifferently, and few trades allow of greater scamping. In first-class work, after the first two coats

have been put on, the paint, when dry, should be rubbed down with pumice-stone before the finishing coats are put on. Inferior painting is so common that it has a demoralizing effect on painters of the day. The quality of the material, especially the white lead, has much to do with the permanency. We find painting done on old work without any cleaning, stopping or even pumicing. A slovenly and inartistic class of grainers are also met with, who repaint and regrain on work that ought to be well rubbed with pumice-stone or sand-paper before the first new coat is laid.

For painting three coats, the following materials are given tor 100 superficial feet of new work: Paint, eight pounds; boiled linseed oil, three pints; spirits of turpentine, one pint; the work taking thre men for one day. According to Saxton, forty-five yards of first coat, including stopping, will require five pounds of white lead, five pounds of putty, one quart of oil. The same quantity of each succeeding coat will require the same allowance of white lead and oil. The best materials will last for seven years, but the ordinary painting seldom lasts three.

THE ANNUAL RING IN TREES.

The annual rings in trees exist as such in all timber grown in the temperate zone. Their structure is so different in different groups of timber that, from their appearance alone, the quality of the timber may be judged to some extent. For this purpose the absolute width of the rings, the regularity in width from year to year and the proportion of spring wood to autumn wood must be taken into account. Spring wood is characterized by less substantial elements, the vessels of thin-walled cells being in greater abundance, while autumn wood is formed of cells with thicker walls, which appear darker in color. In conifers and deciduous trees the annual rings are very distinct, while in trees like the birch, linden and maple the distinction is not so marked, because the vessels are more evenly distributed. Sometimes the gradual change in appearance of the annual ring from spring to autumn wood, which is due to the difference in its component elements, is interrupted in such a manner that a more or less pronounced layer of autumn wood can apparently be recognized, which again gradually changes to spring or summer wood, and then gradually finishes with the regular autumn wood. This irregularity may occur even more than once in the same ring, and this has led to the notion that the annual rings are not a true indication of age; but the double or

counterfeit rings can be distinguished by a practiced eye with the aid of a magnifying glass. These irregularities are due to some interruptions of the functions of the tree, caused by defoliation, extreme climatic condition or sudden changes of temperature. The breadth of the ring depends on the length of the period of vegetation; also when the soil is deep and rich, and light has much influence on the tree, the rings will be broader. The amount of light, and the consequent development of foliage, is perhaps the most powerful factor in wood formations, and it is upon the proper use of this that the forester depends for his means of regulating the development and quantity of his crop.

POINTERS FOR ARCHITECTS, BUILDERS AND WOOD-WORKERS.

A box of window-glass contains fifty feet of glass, regardless of size of sheets.

African teak-wood outlasts any other kind of wood. It is the only wood found preserved in Egyptian tombs 4,000 years old. It shrinks only "on end."

It is a common practice in France to coat the beams, the joists and the under side of the flooring of buildings with a thick coating of lime-wash as a safeguard against fire. It is a preventive of prime ignition, although it will not check a fire when once under headway.

Any beam, whether of wood or iron, is as much stronger when placed on its edge as when on its side, as the width is greater than the thickness. Thus a stick or bar of iron one inch by three inches when used as a beam is three times as strong when placed on its edge as when on its side. This is true only within limits. It would not be true of a piece of boiler-plate, on account of the flexibility.

Mortar made in the following manner will stand if used in almost all sorts of weather: One bushel of unslaked lime, three bushels of sharp sand; mix 1 lb. of alum with one pint of linseed oil, and thoroughly mix this with the mortar when making it, and use hot. The alum will counteract the action of the frost on the mortar.

A new system of building houses of steel plates is being introduced by M. Danly, manager of the Société des Forges de Chateleneau. It has been found that corrugated sheets only a millimetre in thickness are sufficiently strong for building houses several stories high, and the material used allows of architectural ornamentation. The plates used are of the

finest quality, and as they are galvanized after they have been cut to the sizes and shapes required, no portion is left exposed to the action of the atmosphere. Houses so constructed are very sanitary, and the necessary ventilating and heating arrangements can readily be carried out.

Moisture-proof glue is made by dissolving 16 ounces of glue in 3 pints of skim milk. If a still stronger glue be wanted, add powdered lime.

Shellac and borax boiled in water produces a good stain for floors.

Don't inclose the sink — no place in a kitchen is so much neglected.

Porch floors should be of narrow stuff and the joints laid in white lead.

Lime-water is fire-proof protection for shingles or any light wood-work.

Common brick absorb a pint of water each, and make a very damp house.

The lowest-priced builder is not always the cheapest, as poor work will testify.

A closet finished with red cedar shelves and drawers is death to moths and insects.

Do not locate a furnace register next to a mantel — that is, if you wish to utilize the heat.

Terra-cotta flue linings are a great improvement over the old, roughly plastered chimney.

For basement flooring, oak is preferred to maple because it will stand dampness better.

To properly select the colors applicable to the proper place, consult an educated painter.

A ventilating flue from the kitchen into the chimney often does away with atmospheric meals.

Stops to doors and windows should be fastened with roundhead screws, so as to be easily moved.

It is better to oil floors than to paint them — a monthly rubbing will make them as good as new.

Do not use one chimney-flue for two stove pipes — the draft of one will counteract that of the other.

Do not finish windows to the floor — the circulation across the floor is one of the causes of cold houses.

Ash-pits in cellars under fire-places and mantels save taking up ashes, for they may be raked down through a hopper.

Do not construct solid doors of two kinds of hardwood — the action of the atmosphere on one or the other will cause the door to warp.

HINTS ON VENTILATION.

In ventilating — say, a bed-room — by means of the window, what you may principally want is an upward-blowing current. Well, there are several methods of securing this without danger of a draught.

1. Holes may be bored in the lower part of the upper sash of the window, admitting the outside air.

2. Right across one foot of the lower sash, but attached to the immovable frame of the window, may be hung or tacked a piece of strong Willesden paper — prettily painted with flowers or birds, if you please. The window may then be raised to the extent of the breadth of this paper, and the air rushes upward between the two sashes.

3. The same effect is got from simply having a board about six inches wide and the exact size of the sash's breadth. Use this to hold the window up.

4. This same board may have two bent or elbow tubes in it, opening upward and into the room, so that the air coming through does not blow directly in. The inside openings may be protected by valves, and thus the amount of incoming current can be regulated. We thus get a circulating movement of the air, as, the window being raised, there is an opening between the sashes.

5. In summer a frame half as big as the lower sash may be made of perforated zinc or wire gauze and placed in so as to keep the window up. There is no draught; and, if kept in position all night, then, as a rule, the inmate will enjoy refreshing sleep.

6. In addition to these plans, the door of every bedroom should possess, at the top thereof, a ventilating panel, the simplest of all being that formed of wire gauze.

In conclusion, let me again beg of you to value fresh air as you value life and health itself; while taking care not to sleep directly in an appreciable draught, to abjure curtains all round the bed. A curtained bed is only a stable for nightmares and an hotel for a hundred wonder-ills and ailments.

STRENGTH OF ICE.

Ice two inches thick will bear men to walk on.

Ice four inches thick will bear horses and riders.

Ice eight inches ihick will bear teams with very heavy loads.

Ice ten inches thick will sustain a pressure of 1,000 pounds per square foot.

THE FORESTS OF THE UNITED STATES.

The total area of forest lands in the United States and Territories, according to the annual report of the Division of Forestry of the Department of Agriculture, is 465,795,000 acres. The State which has the largest share is Texas, which is credited with 40,000,000 acres. Minnesota comes next with 30,000,000, then Arkansas, with 28,000,000; and Florida, Oregon, California and Washington Territory are put down at 20,000,000 each. Georgia and North Carolina have each 18,000,000; Wisconsin and Alabama, each 17,000,000; Tennessee, 16,000,000; Michigan, 14,000,000; and Maine, 12,000,000 acres. Taking the States in groups, the six New England States have, in round numbers, 19,000,000 acres; four Middle States, 18,000,000; nine Western States, 80,000,000; four Pacific States, 53,000,000; seven Territories, 63,000,000; and fourteen Southern States, 233,000,000 acres, or almost precisely half of the whole forest area of the country.

Reviewing the figures given by the department, the *Tradesman*, of Chattanooga, Tenn., makes the following instructive comment: "These statistics show that, while the process of denudation has been carried on to an unhealthy extreme in the Eastern, Middle and a few of the Western States, the forest area still remaining in this country is a magnificent one. If the estimates of the department are approximately correct, the timber lands of the country, exclusive of Alaska, cover an area equal to fifteen States the size of Pennsylvania. If proper measures are taken to prevent the rapid and unnecessary destruction of what is left of our forest domain, it should be equal to all requirements for an indefinite period. It is not yet a case of locking the stable after the horse is stolen, and never should be allowed to become so. With the adoption the policy of judicious tree planting in the prairie States, and a system of State or government reservations in the mountainous districts, which are the sources of the chief rivers of the country, the evil effects which have followed forest denudation in Europe and some portions of Asia would never exist here."

TO FIND THE WEIGHT OF GRINDSTONES.

.06363 times square of inches diameter, times thickness in inches = weight of grindstone in lbs.

3.1415926 = ratio of diameter to circumference of circle.

ALTITUDE ABOVE THE SEA-LEVEL OF VARIOUS PLACES IN THE UNITED STATES.

Portland, Me.	185	Knoxville, Tenn	1,[illegible]
Concord, N. H.	375	Louisville, Ky.	449
Cleveland, O.	645	Cincinnati, O.	480
Detroit, Mich.	595	Upper portion of [illegible]	588
Mt. Washington	6,293	San Francisco, Cal.	130
Ann Arbor, Mich.	890	Indianapolis, Ind.	700
Boston, Mass.	82	Chicago, Ill.	581
Albany, N. Y	75	Milwaukee, Wis.	590
New York, N. Y.	60	St. Anthony Falls, Minn.	822
Buffalo, N. Y.	580	Dubuque, Ia.	1,400
Philadelphia, Penn	60	St. Louis, Mo.	480
Pittsburg, Penn.	935	Omaha, Neb.	1,300
Baltimore, Md.	275	Lawrence, Kan.	803
Washington, D. C.	92	Fort Phil Kearney, Wy.	6,000
Charleston, S. C.	27	Yankton, Dak.	1,900
Vicksburg, Miss.	352	Fort Garland, Colo.	8,365
New Orleans, La.	10	Salt Lake City, Utah	4,322
El Paso, Texas	3,831	Sacramento, Cal.	22

VALUE OF LEAVES AS PURIFIERS.

A single tree, through its leaves, is capable of purifying the air of the carbonic acid which has been exhaled by a dozen individuals, or even a score. A human being exhales, in the course of 24 hours, about 100 gallons of carbonic acid. According to Boussingault's estimate a single square yard of leaf surface, counting both the upper and the under sides of the leaves, can, under favorable circumstances, decompose at least a gallon of carbonic acid in a day. One hundred square yards of leaf surface then would suffice to keep the air pure for one man. but the leaves of a tree of moderate size present a surface of many hundred square yards.

HOW TO POLISH ZINC.

We have been successful in polishing zinc with the following solution: To 2 quarts of rainwater add 3 oz. powdered rotten stone, 2 oz. pumice stone, and 4 oz. oxalic acid Mix thoroughly, and let it stand a day or two before using. Stir or shake it up when using, and, after using, polish the zinc with a dry woolen cloth or chamois skin. The more thoroughly the zinc is rubbed the longer it will stay bright.

HOW TO MAKE A GOOD FLOOR.

Nothing attracts the attention of a person wishing to rent or purchase a dwelling, store or office, so quickly as a handsome, well-laid floor, and a few suggestions on the subject, though not new, may not be out of place.

The best floor for the least money can be made of yellow pine, if the material is carefully selected and properly laid.

First, select edge-grain yellow pine, not too "fat," clear of pitch, knots, sap and splits. See that it is thoroughly seasoned, and that the tongues and grooves exactly match, so that, when laid, the upper surfaces of each board are on a level. This is an important feature often overlooked, and planing-mill operatives frequently get careless in adjusting the tonguing and grooving bits. If the edge of a flooring board, especially the grooved edge, is higher than the edge of the next board, no amount of mechanical ingenuity can make a neat floor of them. The upper part of the groove will continue to curl upward as long as the floor lasts.

Supposing, of course, the sleepers, or joists, are properly placed the right distance apart, and their upper edges precisely on a level, and securely braced, the most important part of the job is to "lay" the flooring correctly. This part of the work is never, or very rarely ever, done nowadays. The system in vogue with carpenters of this day, of laying one board at a time, and "blind nailing," is the most glaring fraud practiced in any trade. They drive the tongue of the board into the groove of the preceding one, by pounding on the grooved edge with a naked hammer, making indentations that let in the cold air or noxious gases, if it is a bottom floor, and then nail it in place by driving a six-penny nail at an angle of about 50° in the groove. An awkward blow or two chips off the upper part of the groove, and the last blow, designed to sink the nail-head out of the way of the next tongue, splits the lower part of the groove to splinters, leaving an unsightly opening. Such nailing does not fasten the flooring to the sleepers, and the slanting nails very often wedge the board up so that it does not bear on the sleeper. We would rather have our flooring in the tree standing in the woods than put down that way.

The proper plan is to begin on one side of the room, lay one course of boards with the tongue next to, and neatly fitted to, the wall (or studding, if a frame house), and be sure the boards are laid perfectly straight from end to end of the room and square with the wall. Then nail this course firmly to the sleepers, through and through, one nail near

each edge of the board on every sleeper, and you are ready to begin to lay a floor. Next, fit the ends and lay down four or six courses of boards (owing to their width). If the boards differ widely in color, as is often the case in pine, do not lay two of a widely different color side by side, but arrange them so that the deep colors will tone off into the lighter ones gradually. Push the tongues into the grooves as close as possible, without pounding with a hammer, or, if pounding is necessary, take a narrow, short piece of flooring, put the tongue in the groove of the outer board, and pound gently on the piece, never on the flooring board. Next, adjust your clamps on every third sleeper and at every end joint, and drive the floor firmly together by means of wedges. Drive the wedges gently at the start, and each one equally till the joints all fill up snugly, and then stop, for, if driven too tight, the floor will spring up. Never wedge directly against the edge of the flooring board, but have a short strip with a tongue on it between the wedge and the board, so as to leave no bruises. Then fasten the floor to the sleepers by driving a flat-headed steel wire nail of suitable size, one inch from either edge of every board, straight down into each sleeper. At the end-joints smaller nails may be used, two nails in board near the edges, and as far from the ends as the thickness of the sleeper will permit. Proceed in this manner until the floor is completed, and you will have a floor that will remain tight and look well until worn out.

Such minute directions, for so common and simple a job, sound silly, but are justifiable from the fact that there are so many alleged carpenters who either do not know how or are too lazy to lay a floor properly.

GLUE FOR DAMP PLACES.

For a strong glue, which will hold in a damp place, the following recipe works well: Take of the best and strongest glue enough to make a pint when melted. Soak this until soft. Pour off the water, as in ordinary glue-making, and add a little water if the glue is likely to be too thick. When melted, add three table-spoonfuls of boiled linseed oil. Stir frequently, and keep up the heat till the oil disappears, which may take the whole day, and perhaps more. If necessary, add water to make up for that lost by evaporation. When no more oil is seen, a tablespoonful of whiting is added and thoroughly incorporated with the glue.

MORTAR MAKING.

Much depends on having mortar made on correct, if not scientific, principles. The durability, if not the actual safety, of a building is more or less affected by the kind of mortar that is put into it. We have seen brick buildings, and not very old ones either, from which the dry and hardened mortar could easily be picked in cakes from between the bricks. The advantage of using such mortar is, that, when the building tumbles down, there will be no trouble in picking from it the old bricks, preparatory to rebuilding. A brick wall, if put up with the right kind of mortar, will be solid and almost homogeneous, as likely to break through the middle of the bricks as at the joints. Such a building will never tumble down, except under great strain, and will withstand a pretty severe earthquake shock.

An old builder, of nearly forty years' experience in making mortar, writing upon the subject to a contemporary, very justly says: "The mere matter of slacking lime does not make mortar out of it. Lime and water alone will not make any better mortar than sand and water." He suggests the use of plenty of water in slacking the lime, so that, when it is run out of the box into the bed, it will not bake or burn, as it is liable to do, if not well watered. The mortar bed should be large and tight, so there will be no leakage of the lime water. The proportion should be about fifty yards of good sand to twenty-five barrels of lime, for the first mixing, which should be thoroughly done. The hair should be put into the lime before mixing in the sand. After the mortar has been mixed in the above proportions for ten days or more, if the amount of materials given have been used, twenty-five to fifty loads of sand may be added and worked in. It is said that the water that rises on a bushel of slaked lime, and where plenty of water has been used, if removed and put on a sharp sand, will make better stone than lime and sand mixed, showing that the water should be retained in the sand and lime while it is fresh, and that the mortar should be tempered in its own liquor. Of course, where smaller quantities are used, the proportion should be retained, both at the first mixing and in the sand added subsequently.

A pound of ten-penny cut nails will do as much work as two pounds of wire nails. Taking the average of all cut nails, they are worth nearly double as much as wire nails, from tests made at the Watertown Government Arsenal.

COST OF EXCAVATING AND HANDLING ROCK.

The average weight of a cubic yard of sandstone or conglomerate, in place, is given as 1.8 tons, and of compact granite, gneiss, limestone or marble, 2 tons, or an average of 1.9 tons, or 4,256 pounds. A cubic yard, when broken up ready for removal, increases about four-fifths in bulk, and $\frac{1}{14}$ of a cubic yard, 177 pounds, is a wheelbarrow load. Experience shows that, with wages at $1 per day of 10 hours, 45 cents per cubic yard is a sufficient allowance for loosening hard rock. Soft shales and allied rocks may be loosened by pick and plow at a cost of 20 cents to 30 cents per cubic yard. The quarrying of ordinary hard rock requires from ¼ pound to ⅓ pound and sometimes ½ pound of powder per cubic yard. Drilling with a churn driller costs from 12 to 18 cents per foot of hole bored. Upon these data, Mr. Rigly estimates the total cost, per cubic yard of rock in place, for loosening and removing by wheelbarrow (labor assumed at $1 per day of 10 hours), as follows: When distance removed is 25 feet, total cost=$0.537; when 50 feet, $0.549; when 100 feet, $0.573; when 200 feet, $0.622; when 500 feet, $0.768; when 1,000 feet, $1.011; and when 1,800 feet, $1.401. This is exclusive of contractor's profit.

When labor is $1.25 per day, add 25 per cent. to the cost prices given; when $1.50 per day, add 50 per cent. and so on. In hauling by cart, the cost of loading, which will be about 8 cents per cubic yard of rock in place, and the additional expense of maintaining the road must be added. Allowing, then, 851 pounds as a cart-load, the total cost per cubic yard is estimated, when removed 25 feet, at $0.596; when 50 feet, $0.599; when 100 feet, $0.605; when 200 feet, $0.617; when 500 feet, $0.655; when 1,000 feet, $0.717; and when 1,800 feet, $0.94.

IRON BRICK.

It is reported that the German Government testing laboratory for building materials has reported favorably on a new paving-block called iron brick. This brick is made by mixing equal parts of finely-ground clay, and adding 5 per cent. of iron ore. This mixture is moistened with a solution of 25 per cent. sulphate of iron, to which fine iron ore is added until it shows a consistency of 38 degrees Baume. It is then formed in a press, dried, dipped once more in a nearly concentrated solution of sulphate of iron and finely ground iron ore, and is baked in an oven for 48 hours in an oxidizing flame, and 24 hours in a reducing flame.

DRY ROT IN TIMBER.

No wood which is liable to damp, or has at any time absorbed moisture, and is in contact with stagnant air, so that the moisture cannot evaporate, can be considered safe from the attack of dry rot.

Any impervious substance applied to wood, which is not thoroughly dry, tends to engender decay; floors covered with kamptulicon and laid over brick arching before the latter was dry; cement dado to wood partition, the water expelled from dado in setting, and absorbed by the wood, had no means of evaporation.

Woodwork coated with paint or tar before thoroughly dry and well seasoned, is liable to decay, as the moisture is imprisoned.

Skirtings and wall paneling very subject to dry rot, and especially window backs, for the space between woodwork and the wall is occupied by stagnant air; the former absorbs moisture from the wall (especially if it has been fixed before the wall was dry after building), and the paint or varnish prevents the moisture from evaporating into the room. Skirting, etc., thus form excellent channels for the spread of the fungus.

Plaster seems to be sufficiently porous to allow the evaporation of water through it; hence, probably, the space between ceiling and floor is not so frequently attacked, if also the floor boards do not fit very accurately and no oil cloth covers the floor.

Plowed and tongue floors are disadvantageous in certain circumstances, as when placed over a space occupied by damp air, as they allow no air to pass between the boards, and so dry them.

Beams may appear sound externally and be rotten within, for the outside, being in contact with the air, becomes dryer than the interior. It is well, therefore, to saw and reverse all large scantling.

The ends of all timber, and especially of large beams, should be free (for it is through the ends that moisture chiefly evaporates). They should on no account be imbedded in mortar.

Inferior and ill-seasoned timber is evidently to be avoided.

Whatever insures dampness and lack of evaporation is conducive to dry-rot, that is to say, dampness arising from the soil; dampness arising from walls, especially if the damp-proof course has been omitted; dampness arising

from use of salt sand ; dampness arising from drying of mortar and cement.

Stagnation of air resulting from air grids getting blocked with dirt or being purposely blocked through ignorance. Stagnation may exist under a floor although there are grids in the opposite walls, for it is difficult to induce the air to move in a horizontal direction without some special means of suction. Corners of stagnant air are to be guarded against.

Darkness assists the development of fungus; whatever increases the temperature of the wood and stagnant air (within limits) also assists.

PAINTING FLOORS.

Colors containing white lead are injurious to wood floors, rendering them softer, and more liable to be worn away Paints containing mineral colors only, without white lead, such as yellow ochre, sienna or venetian or Indian red, have no such tendency to act upon the floor, and may be used with safety. This quite agrees with the practice common in this country, of painting floors with yellow ochre or raw umber or sienna. Although these colors have little body, compared with the white-lead paint, and need several coats, they form an excellent and very durable covering for the floor. Where a floor is to be varnished, it is found that varnish made by drying lead salts is nearly as injurious as lead paint. Instead of this, the borate of manganese should be used to dispose the varnish to dry, and a recipe for a good floor varnish is given. According to this, two pounds of pure white borate of manganese, pounded very fine, are to be added, little by little, to a saucepan containing ten pounds of linseed oil, which is to be well stirred, and gradually raised to a temperature of three hundred and sixty degrees Fahrenheit. Meanwhile, heat one hundred pounds linseed oil in a boiler until bubbles form; then add to it slowly the first liquid, increase the fire, and allow the whole to cook for twenty minutes, and finally remove from the fire, and filter while warm through cotton cloth The varnish is then ready, and can be used immediately. Two coats should be used, and a more brilliant surface may be obtained by a final coat of shellac.

The railroads consume half of the coal used in this country.

COLD WATER SUPPLY PIPES.

The following matter, in catechetical form, illustrates the teachings of the New York Trades Schools in this connection :

1.—What size should the pipe from the street main to the house be ?

A.—The supply pipes of New York average about 1¼ to 1½ inches in diameter.

2.—What material is used for this pipe in New York ?

A.—Mostly lead pipes.

3.—What other materials, besides lead, are used for supply pipes ?

A.—Galvanized iron, brass, and tin-lined lead pipes.

4.—How is iron used ?

A.—Plain, galvanized, and lined with tin or glass.

5.—What are the advantages and disadvantages of lead pipes ?

A.—Advantages are its ductility, strength, and easiness of working, also its durability. Disadvantages are danger of poisoning the water, and of being eaten by rats.

6.—What are the advantages and disadvantages of plain iron pipe ?

A.—Advantages are cheapness, easiness of putting together, and freedom from poisoning. Disadvantages are rusting, and filling up of pipes.

7.—What are the advantages and disadvantages of tin-lined pipes ?

A.—Advantage is in its freedom from poisoning water. Disadvantage in not being durable for hot-water pipes.

8.—What are the advantages and disadvantages of glass-lined pipe ?

A.—Glass-lined pipe makes an excellent water pipe, but is liable to break in working and putting up.

9.—What are the advantages and disadvantages of galvanized iron pipe ?

A.—Galvanized iron pipe is cheap and free from rust, but some water decomposes zinc, and its salts are poisonous.

10.—What are the advantages and disadvantages of brass pipe?

A.—When brass pipe is lined with tin it is very light and strong; but, when the tin wears off, there is danger of poisoning the water.

11.—What are the advantages and disadvantages of block-tin pipe ?

A.—They are not durable for hot water, and are very expensive.

12.—What are the advantages and disadvantages of tin-lined lead pipe ?

A.—They are not durable.

13.—In using tin-lined lead pipe, what must be guarded against?

A.—The lining must not be disturbed or the tin melted out.

14.—How should the supply pipe be connected with street mains?

A.—By a brass tap and coupling.

15.—How should a lead pipe be joined to an iron pipe?

A.—By a brass spud or soldering nipple.

16.—Should the supply pipe be so arranged that it can be emptied? and why?

A.—Yes. To prevent freezing, and the water from stagnating in the pipe.

17.—What precaution can be taken against freezing if the main is within three feet of surface?

A.—By bending the pipe a few feet lower at the main, and continuing the pipe at the lower level.

18.—In crossing an area with a supply pipe, what precaution should be taken?

A.—Cover the pipe with felt, or put it in a box filled with saw-dust, to prevent freezing?

19.—What is gained by putting a supply pipe from street main to house in a larger iron pipe?

A.—The air in a larger iron pipe protects the supply, and steam can be injected to thaw pipe if it freezes.

20.—How can water supply be increased after service pipe enters house?

A.—The flow of water can be greatly assisted by using a larger pipe after entering the house.

21.—Is there any way to arrange a pipe so that drawing water from a lower floor will not stop or retard the flow from upper floors ?

A.—The best way would be to proportion branches on different floors according to pressure ; the smaller the pressure the larger the outlet.

22.—Suppose a three-story house had a $\frac{5}{8}$ tap from main to house, and connected from this tap to top of boiler with a $1\frac{1}{4}$ inch pipe ; what size should the branch pipes to basement fixtures be ?

A.—One-half to five-eighths should be large enough.

23.—The parlor floor contains a pantry sink, a wash-

basin and a water-closet ; how large should the supply pipe from basement to parlor floor be ?

A.—About 1 inch in diameter.

24.—How large the branch pipes to fixtures ?

A.- ½ to ⅝ in diameter.

25.—The second floor contains a bath, two water-closets and five wash-basins ; how large should the pipe from parlor to second floor be ?

A.—About 1 inch in diameter.

26.—How large should the pipe from basement to tank be ?

A.—About 1¼ inch in diameter.

27.—In a building of six or more stories in height with cold water supply drawn from tank on upper floors, does any difficulty occur ?

A.—Yes. On the lower floors the pressure is to great.

28.—How can it be remedied ?

A.—By diminishing branch pipes to give a proportional supply.

29.—Can supply pipe be so arranged that water can be drawn from the main or from tank?

A.—Yes. By using a special stop-cock for the purpose.

30.—What precautions should be taken to prevent pipes freezing ?

A.—By placing as far from frost as possible, and by proper boxing and felting.

31.—Why are pipes liable to burst when they freeze ?

A.—The expansion expands the pipes, and, consequently, they burst.

32.—What is the expanding pressure of freezing water ?

A.—Thirty thousand pounds to the square inch.

33.—What means are taken to thaw out a service-pipe ?

A.—The application of heat externally or steam and hot water internally is about the best means.

34.—Is the external application of heat objectionable with iron pipes ?

A.—Yes ; as the sudden contraction is as dangerous as the expansion.

35.—In carrying supply pipes across a floor, what precaution can be taken to protect ceiling below from a leak ?

A.—By putting pipes in a box lined with lead, and having a waste, or tell-tale, pipe at lowest point.

36.—Does fresh mortar injure lead pipes ?

A.—As the lime in fresh mortar is corrosive and forms a soluble compound, it is an injury to lead pipes.

PRESSURES ON TANKS.

Q.—In a full cubical tank, what is the pressure on any vertical side ?

A.—One-half the weight of the contents.

Q.—In a full conical vessel standing on its base, what is the pressure on the base ?

A.—Three times the weight of the contents.

Q.—In a hollow sphere, full of liquid, which is the pressure on the surface of the lower half ?

A.—Three times the weight of contents.

TINNING BY SIMPLE IMMERSION.

Argentine is a name given to tin precipitated by galvanic action from its solution. This material is usually obtained by immersing plates of zinc in a solution of tin, containing 6 grammes (about 90 grains) of the metal to the litre (0.88). In this way tin scrap can be utilized. To apply the argentine according to M. P. Marino's process, a bath is prepared from argentine and acid tartrate of potash, rendered soluble by boric acid. Pyrophosphate of soda, chloride of ammonium, or caustic soda may be substituted for the acid tartrate. The bath being prepared, the objects to be coated are plunged therein, first having been suitably pickled and scoured, and they may be subjected to the action of an electric current. But a simple immersion is enough. The bath for this must be brought to ebullition, and the objects of copper or brass, or coated therewith, may be immersed in it.

HOW TO FIND THE AMOUNT OF STEAM-PIPE REQUIRED TO HEAT A BUILDING WITH STEAM.

Rule for finding the superficial feet of steam-pipe required to heat any building with steam : One superficial foot of steam-pipe to six superficial feet of glass in the windows, or one superficial foot of steam-pipe for every hundred square feet of wall, roof or ceiling, or one square foot of steam-pipe to eighty cubic feet of space. One cubic foot of boiler is required for every fifteen hundred cubic feet of space to be warmed. One horse-power boiler is sufficient for forty thousand cubic feet of space Five cubic feet of steam, at seventy-five pounds pressure to the square inch, weighs one pound avoirdupois.

SEASONING TIMBER.

Timber, when freshly cut, contains from thirty-seven to forty-eight per cent. of water, the kind, the age, and the season of vegetation governing the percentage. Older wood is generally heavier than young wood, and the weight of wood cut in the active season is greater than that of wood cut in the dormant season. Water in wood is not chemically combined with the fiber, and, when exposed to the atmosphere, the moisture evaporates. The wood becomes lighter until a certain point is reached in the drying-out process, after which it gains or loses in the weight according to the variations in the moisture and temperature of the atmosphere. Following is a table showing the percentage in weight of water in round woods from young trees at different lengths of time after cutting:

Kind of Wood.	6 mos.	12 mos.	18 mos.	24 mos.
Beech	30.44	23.46	18.60	19.95
Oak	32.71	26.74	23.25	20.28
Hornbeam	27.19	23.08	20.00	18.59
Birch	39.72	29.01	22.73	19.52
Poplar	40.45	26.22	17.77	17.92
Fir	33.78	16.87	15.21	18.00
Pine	41.70	18.67	15.63	17.42

According to these figures, taken from actual trials, there is nothing gained by keeping wood longer than eighteen months, so far as drying or seasoning is concerned. In the woods mentioned, there appears to be an actual loss in some, and only a slow gain in others after that length of time. The pine, fir, and beech gained moisture, and the others in the list lost only very slightly after the eighteen months had passed.

PROPOSED GREAT ENGINEERING FEAT.

A gigantic scheme has been proposed, by which the cañons of the Rocky Mountains are to be dammed up from the Canadian boundary to Mexico, in order to form vast reservoirs of water to be used in the irrigation of arid lands, and so prevent floods in the lower Mississippi. Major Powell, director of the national survey, estimates that at least 150,000 square miles of land might thus be reclaimed — a territory exceeding in extent one-half of the land now cultivated in the United States. The plan is to build dams across all the cañons in the mountains large enough and strong enough to hold back the floods from heavy rains and melting snows, and then let the water down as it may be needed upon the land to be reclaimed.

ON THE USE OF GLUE.

In order to use glue successfully, says a writer of experience, a great deal of experience is required, and it is useless for the amateur to try it; he will only spoil the work. So, unless the workman is well experienced in the treatment and the application of the glue, he had better leave it alone entirely. To render the operation successful, two considerations must be taken into account: First, to do good gluing requires that the timber be well seasoned and thoroughly dry, taking care that the joints to be glued are well fitted. Second, in preparing the parts to be glued, each piece should be scratched with a sharp file or piece of a fine saw, to make the glue hold better. The shop should be kept at a proper temperature, and the material heated so that the glue may flow quite freely. Having the glue properly prepared, spread it evenly upon the parts so as to fill up the pores and grain of the wood, then put the pieces together as rapidly as possible, using clamps and thumb-screws to draw the joints tightly together; all superfluous glue should be washed off, taking great care not to use too much water, or allowing any to remain on the pieces put together. The greatest cause of bad gluing is in using inferior glue and in laying it on unevenly. Before using a new brand of glue it is safer to test it by gluing a piece of whitewood and ash together, clamping it with a thumb-screw, and, when dry, insert a chisel where it is put together, and, if the joint separates where it is glued, it is not fit to use, and should be rejected at once. The wood should split or give way rather than the substance promoting adhesion. This is a practical and severe test, but it will pay to apply it, in the stability of the work.

GLUE PAINT FOR KITCHEN FLOOR.

For a kitchen floor, especially one that is rough and uneven, the following glue paint is recommended: To three pounds of spruce yellow add one pound, or two pounds if desired, of dry white lead, and mix well together. Dissolve two ounces of glue in one quart of water, stirring often until smooth and nearly boiling. Thicken the glue water after the manner of mush, until it will spread smoothly upon the floor. Use a common paint brush and apply hot. This will fill all crevices of a rough floor. It will dry soon, and when dry apply boiled linseed oil with a clean brush. In a few hours it will be found dry enough to use by laying papers or mats to step on for a few days. When it needs cleaning, use hot suds.

EFFECT OF THE ATMOSPHERE ON BRICKS.

Atmospheric influence upon bricks, tiles and other building materials obtained by the burning of plastic clays, depends very much on the chemical composition of the clays and on the degree of burning. Thus, any distinct portions of limestone present in them would be converted into quicklime in the kiln, and, when the bricks were thoroughly wetted, would expand in such a manner as to disintegrate the mass. If the clay used is too poor—that is to say, if it contains an excess of sand—the bricks will not become sufficiently fused, and, upon exposure to the weather, their constituent parts will separate. It is to be observed that in bricks, as in stones, decomposition does not take place with the greatest rapidity where constant moisture exists, but rather where, from the absence of capillarity, variable according to the moisture furnished by the atmosphere, either directly or indirectly, a series of alternations of dryness and humidity prevail.

The foundation walls of buildings do not in fact suffer so much in the parts immediately upon the ground as they do in those at a height of from one to three feet, according to the permeability of the materials employed. When bricks made of clay containing free silica are laid in mortar, and moisture can pass freely from either one or the other, it may be observed that the edges in contact become harder than the body of the bricks. No doubt this arises from the formation of a silicate of lime and alumina, the lime being furnished by the passage of the water through the bed of the mortar.

THE GREAT EIFFEL TOWER.

One of the principal features of interest at the Paris Expositions is the Eiffel tower. It is constructed of iron, and rises to a height of 984 feet. As the greatest height yet reached in any structure is that of the Washington monument, 550 feet, some idea can be formed of the great distance upward that this tower rises. This tower weighs 7,000 tons, and cost 4,500,000 francs. One object of its construction is to light the Exposition grounds. The tower is supplied with elevators landing the passengers 971 feet from the earth. It is also supplied with electric lights of 19,000,000 candle power. Four such towers, with a capacity of 50,000,000 each, it is thought, would light the whole city of Paris. Perhaps this tower will decide the question whether or not it is possible to light an entire city from a few points, if not from one.

ROT IN TIMBER.

The principal cause of the lack of proper durability of timber in buildings is the porosity of the lumber used and the consequent liability to absorb moisture. Coarse-grained woods of quick growth are more liable to this defect than those of tough fiber and slow growth. When timber becomes repeatedly wet and dry, it becomes brittle and weakened, or "its nature is gone," as the workmen say. Rot is of two kinds, wet and dry, and moisture is the essential element in both cases, the only difference being that in the first the moisture is quickly evaporated by exposure to the air, and in the latter, when there is no exposure, it produces a species of fungus and minute worms which eat in between the fibers, and gradually produce disintegration. Sap wood is more perishable than heart wood, for the former contains more of the saccharine principle, and renders the wood liable to a fermentive action.

The prevalent practice of confining unseasoned timber by building it close into walls, thus preventing the ready evaporation of whatever moisture happens to get to it, is a bad one. The ends of the wood, especially, should be surrounded by an open-air space, however small, as it is the ends where the dampness is most liable to penetrate into the structure of the wood. It is a well-known fact that a log of green timber, when kept immersed, will become water-logged and sink, and, of course, become unfit for use afterward. The same process, only slower, applies when it is exposed to damp with no facilities for rapid evaporation. Quicklime, when assisted by moisture, is a powerful aid in hastening decomposition, in consequence of its affinity for carbon. Mild lime has not this effect, but mortar, as used in buildings, requires a considerable length of time to become inert in its action as a corroding agent; therefore bedding timber in damp mortar is very injurious, and often the cause of unaccountable decay. Wood, in a dry state, does not seem to be injured by contact with dry lime, it being rather a preservative. An example of this is shown in lathing covered with plaster, which often retains its original strength when surrounding timbers are completely rotted away.

Anything that will hinder the absorbing process will extend the life of a wood, such as a coating of tar, paint, or a charring of the surface. The latter method will prove the most effective, if sufficiently deep, as the charred coating is practically indestructible, closes the pores of the wood, and will prevent the bursting into flame in case of a fire. If all

joists, girders and inside beams of every kind were treated to a superficial charring process, it would tend, in conjunction with fire-proof paint applied to outside finishing work, to make a building as nearly fire-proof as wood in any condition will allow.

NUMBER OF BRICKS REQUIRED TO CONSTRUCT A BUILDING.

Superficial feet of **Wall.**	Number of Bricks to Thickness of					
	4 Inch	8 Inch	12 Inch	16 Inch	20 Inch	24 Inch
1.......	7	15	22	29	37	45
2.......	15	30	45	60	75	90
3.......	23	45	68	90	113	135
4.......	30	60	90	120	150	180
5.......	38	75	113	150	188	225
6.......	45	90	135	180	225	270
7.......	53	105	158	210	263	315
8.......	60	120	180	240	300	360
9.......	68	135	203	270	338	405
10.......	75	150	225	300	375	450
20.......	150	300	450	600	750	900
30.......	225	450	675	900	1,125	1,350
40.......	300	600	900	1,200	1,500	1,800
50.......	375	750	1,125	1,500	1,875	2,250
60.......	450	900	1,350	1,800	2,250	2,700
70.......	525	1,050	1,575	2,100	2,625	3,150
80.......	600	1,200	1,800	2,400	3,000	3,600
90.......	675	1,350	2,025	2,700	3,375	4,050
100.......	750	1,500	2,250	3,000	3,750	4,500
200.......	1,500	3,000	4,500	6,000	7,500	9,000
300.......	2,250	4,500	6,750	9,000	11,250	13,500
400.......	3,000	6,000	9,000	12,000	15,000	18,000

Sycamore is being introduced quite extensively for interior finish. When properly selected it makes a very handsome finish. Care should be taken in securing it, as it is nearly as bad to warp as elm. It should be well backed with pir spruce or hemlock.

FIRE-PROOFING WOODWORK.

A door of the right construction to resist fire should be made of good pine, and should be of two or more thicknesses of matched boards nailed across each other, either at right angles or at forty-five degrees. If the doorway be more than seven feet by four feet, it would be better to use three thicknesses of same stuff; in other words, the door should be of a thickness proportioned to its area. Such a door should always be made to shut into a rabbet, or flush with the wall when practicable; or, if it is a slide door, then it should be made to shut into or behind a jamb, which would press it up against the wall. Both sides of the door and its jambs, if of wood, should then be sheathed with tin, the plates being locked at joints, and securely nailed under the locking with nails at least one inch long. No air spaces should be left in a door by paneling or otherwise, as the door will resist best that has the most solid material in it. In most places it is much better to fit the door upon inclined metal sliders than upon hinges.

This kind of door may be fitted with automatic appliances, so that it will close of itself when subjected to the heat of a fire; but these appliances do not interfere with the ordinary methods of opening and shutting the door. They only constitute a safegard against negligence.

Under this heading may be classed all the doors of iron, whether sheet, plate, cast or rolled, single, double or hollow, plain or corrugated, none of which are capable of resisting fire for any length of time; also wooden doors covered with tin on one side only, or covered with zinc, which melts at 700 degrees Fahrenheit,

The wooden door covered with tin only serves its purpose when the wood is wholly encased in tin, put on in such a way that no air, or the minimum of air, can reach the wood when it is exposed to the heat of a fire. Under these conditions, the surface of the wood is converted into charcoal; charcoal being a non-conductor of heat, itself tends to retard the further combustion of the wood. But, if air penetrates the tin casing in any measure, the charcoal first made, and then the wood itself, are both consumed, and the door is destroyed. In like manner, if a door is tinned only only on one side, as soon as the heat suffices to convert the surface of the wood under the tin and next to the fire into charcoal, the oxygen reaches it from the outside, and the door is of little more value than a thin door of iron, or plain wooden door.

DIMENSIONS OF THE MOST IMPORTANT OF THE GREAT CATHEDRALS.

	Length, feet.	Breadth, feet.	Height, feet.
St. Peter's	613	450	438
St. Paul's	500	248	404
Duomo	555	240	375
Notre Dame	416	153	298
Cologne	444	283	...
Toledo	395	178	...
Rheims	480	163	117
Rouen	469	146	465
Chartres	430	150	373
Antwerp	384	171	402
Strasbourg	525	195	465
Milan	477	186	360
Canterbury	530	154	235
York	524	261	...
Winchester	554	208	...
Durham	411	170	214
Ely	617	178	...
Salisbury	473	229	279

SUGGESTIONS FOR COLORS.

In forms, tints, and colors the ocean depths supply valuable decorative suggestions. On silverware the iridescent hues of tropical shells are skillfully reproduced, and on ceramic ware their fascinating combinations of tints and the gradations of these shells have been too much hidden away in cabinets, instead of being studied by designers for their elegant curvatures and attractive colors. The delicate and varied hues of the sea anemone, and the curves, volutes and flowing lines of the univalves and bivalves are worthy of patient study with reference to graceful and fanciful ornamentation.

REMOVAL OF OLD VARNISH.

A Mr. Myer has just patented, in Germany, a composition for removing old varnish from objects. It is obtained by mixing five parts of 36 per cent. silicate of potash, one of 40 per cent. soda lye, and one of sal ammoniac (hydrochlorate of ammonia).

DECIMAL EQUIVALENTS OF INCHES, FEET AND YARDS.

Frac. of an Inch.	Dec. of an Inch.	Dec. of a Foot.
1-16	.0625	.00521
⅛	.125	.01041
3-16	.1875	.01562
¼	.25	.02083
5-16	.3125	.02604
⅜	.375	.03125
7-16	.4375	.03645
½	.5	.04166
9-16	.5625	.04688
⅝	.625	.05208
11-16	.6875	.05729
¾	.75	.06250
13-16	.8125	.06771
⅞	.875	.07291

Ins.	Feet.	Yds.
1	.0833	.0277
2	.1666	.0555
3	.25	.0833
4	.3333	.1111
5	.4166	.1389
6	.5	.1666
7	.5833	.1944
8	.666	.2222
9	.75	.25
10	.8333	.2778
11	.9166	.3055
12	1.	.3333

DECIMAL EQUIVALENTS OF OUNCES AND POUNDS.

Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.
¼	.015625	4	.25	8½	.5313
½	.03125	4½	.2813	9	.5625
¾	.046875	5	.3125	10	.625
1	.0625	5½	.3438	11	.6875
1½	.09375	6	.375	12	.75
2	.125	6½	.4063	13	.8125
2½	.15625	7	.4375	14	.875
3	.1875	7½	.4688	15	.9375
3½	.21875	8	.5	16	1.

NOTES ON THE LAW AFFECTING ARCHITECTS.

A person following the occupation of forming plans, drawings and specifications for building purposes, representing himself as an architect, is presumed in law not only as being such, but to be learned in the profession.

If there is any obscurity in the drawings and specifications, the contractor should apply to the architect for directions, or be liable for the consequences.

There is no fixed rule as to compensation of architects in the United States law.

The architect's contract does not survive to his representative. So, if there is a contract to complete certain work

for a certain sum, the representative of a deceased architect cannot recover for the part performance.

In competitions it should always be made clearly understood that the drawings, etc., are subject to approval, for otherwise the party receiving them will be liable for their value, whether used or not.

An architect has not the right to substitute another person in his stead.

If the architect fraudulently or capriciously refuses to give proper certificates when required, the builder may maintain an action for specific performance or against the architect for damages.

PRESERVATION OF WOOD BY LIME.

I have for many years been in the habit of preparing home-grown timber of the inferior sort of fir — Scotch spruce and silver — by steeping it in a tank (that is, a hole dug in clay or peat, which was fairly water-tight) in a saturated solution of lime. Its effect on the sap-wood is to so harden it and fill it with pores that it perfectly resists the attacks of the little wood-boring beetle, and makes it, in fact, equally as durable as the made wood. I had a mill which was lofted with Scotch fir prepared in this way in 1850, and it is in perfect preservation. The timber is packed as closely as it will lie in the tank, water is let in, and unslacked lime is thrown on the top and well stirred about. There is no danger that the solution will not find its way to everything in the tank. I leave the wood in the solution for two or three months, by the end of which time an inch board will be fully permeated by it. Joists and beams would, of course, take a longer time for saturation ; but, in practice, we find that the protection afforded by two or three months' steeping is sufficient, if the scantlings are cut to the sizes at which they are to be used.

A VERY DURABLE WOOD.

The interesting fact is stated that so indestructible by wear or decay is the African teak wood that vessels built of it have lasted one hundred years, to be then only broken up because of their poor sailing qualities from faulty models. The wood, in fact, is one of the most remarkable known, on account of its very great weight, hardness and durability, its weight varying from forty-two to fifty-two pounds per cubic foot. It works easily, but, on account of the large quantity of silex contained in it, the tools employed are quickly worn away. It also contains oil, which prevents spikes and other iron work, with which it comes in contact, from rusting.

HOW TO BUILD AN ICE HOUSE.

1. The ice house floor should be above the level of the ground, or, at least, should be above some neighboring area to give an outfall for a drain, put in such a way as to keep the floor clear of standing water.

2. The walls should be hollow. A four inch lining-wall, tied to the outer wall with hoop iron, and with a three-inch air space, would answer; but it would be better, if the air space is thoroughly drained, to fill it with mineral wool, or some similar substance, to prevent the movement of the air entangled in the fibers, and thus check the transference by convection of heat from the outside of the lining wall.

3. A roof of thick plank will keep out heat far better than one of thin boards with an air space under it.

4. Shingles will be much better for roofing than slate.

5. It is best to ventilate the upper portion of the building. If no ventilation is provided, the confined air under the roof becomes intensely heated in summer; and outlets should be provided, at the highest part, with inlets at convenient points, to keep the temperature of the air over the ice at least down to that of the exterior atmosphere.

TESTING EXTERIOR STAINS.

Since the use of stains for exterior work became so general, several stains, some good and some bad, have appeared on the market, so that a few points on estimating their comparative values may not be amiss.

The nose, and, to a less degree, the eye, are admirable allies for this work, but, unassisted, are not infallible. The following is about the simplest method of testing:

1. Search for kerosene by warming, and then noting the smell. Also, note the thinness and lack of covering power which kerosene causes. Kerosene is simply a cheapener.

2. See how fine it brushes out on a smooth shingle. There should not be the slightest grit or any perceptible grains of pigment, the presence of which will prove that the coloring was mixed dry with the vehicle, and was never ground fine.

3. Pour out some of the stain in a tumbler. If it begins to settle at once, except in the case of a chrome yellow or green, it is made as above stated, by mixing a dry paint with the vehicle, and therefore should be avoided.

A well-ground oil stain tested in this way held up a whole day, and a creosote stain a day and a half.

Of course, when debating between two stains, it is best

to try them side by side. In such case the comparative color-strength may be determined by diluting equal quantities of both stains at about the same shade, with equal quantities of turpentine, and then applying the diluted colors to wood, and noting the depth of the color. One part of stain to ten parts of turpentine is a good strength.

HOW TO PREPARE CALCIMINE.

Soak one pound of white glue over night; then dissolve it in boiling water, and add twenty pounds of Paris white, diluting with water until the mixture is of the consistency of rich milk. To this any tint can be given that is desired.

Lilac—Add to the calcimine two parts of Prussian blue and one of vermilion, stirring thoroughly, and taking care to avoid too high a color.

Gray—Raw umber, with a trifling amount of lamp-black.

Rose—Three parts of vermilion and one of red lead, added in very small quantities until a delicate shade is produced.

Lavender—Mix a light blue, and tint it slightly with vermilion.

Straw—Chrome yellow, with a touch of Spanish brown.

Buff—Two parts spruce, or Indian yellow, and one part burnt sienna.

HOW BASSWOOD MOLDINGS ARE MADE.

Basswood may be enormously compressed, after which it may be steamed and expanded to its original volume. Advantage has been taken of this principle in the manufacture of certain kinds of moldings. The portions of the wood to be left in relief are first compressed or pushed down by suitable dies below the general level of the board, then the board is planed down to a level surface, and afterward steamed. The compressed portions of the board are expanded by the steam, so that they stand out in relief.

BUILDING BLOCKS MADE OF CORNCOBS.

Building blocks made of corncobs form the object of a new Italian patent. The cobs are pressed by machinery into forms similar to bricks, and held together by wire. They are made water-tight by soaking with tar. These molds are very hard and strong. Their weight is less than one-third of that of hollow brick, and they can never get damp.

REDWOOD FINISH.

The following formula and directions have been highly recommended.

Take one quart spirits turpentine.
Add one pound corn starch.
Add ¼ " burnt sienna.
Add one tablespoonful raw linseed oil.
Add " " brown Japan.

Mix thoroughly, apply with a brush, let it stand say fifteen minutes; rub off all you can with fine shavings or a soft rag, then let it stand *at least twenty-four hours*, that it may sink into and *harden* the fibers of the wood; afterward apply two coats of white shellac, rub down well with fine flint paper, then put on from two to five coats best polishing varnish; after it is well dried, rub with water and pumice-stone ground very fine, stand a day to dry; after being washed clean with chamois, rub with water and rotten-stone; dry, wash as before clean, and rub with olive oil until dry.

Some use cork for sand-papering and polishing, but a smooth block of hard wood, like maple, is better. When treated in this way, redwood will be found the peer of any wood for real beauty and life as a house trim or finish.

A NEW WALL PLASTER.

A new material for use instead of common plaster is now prepared, which offers many advantages, as it can be applied more quickly, and dries in less than twenty-four hours. It is impervious to dampness, and there is no possibility of the window and door casings contracting or swelling and causing cracks, as very little water is required in the mixing. It is known as "Adamant" wall-plaster, and deserves its name, as, when once dry, it is very hard to break. From a sanitary point of view, it is also valuable, as it is non-absorbent.

A RELIABLE CEMENT.

A reliable cement, one that will resist the action of water and acids, especially acetic acid, is: Finely powdered litharge, fine, dry white sand and plaster of Paris—each three quarts by measure—finely pulverized resin one part. Mix and make into a paste with boiled linseed oil, to which a little dryer has been added, and let it stand for four or five hours before using. After fifteen hours' standing, it loses strength. The cement is said to have been successfully used in Zoological Gardens, London.

PAVEMENTS.

Bricks, impregnated at a warm temperature with asphaltum, have been successfully used in Berlin, for street pavement. After driying out the water with heat, bricks will take up from fifteen to thirty per centum of bitumen, and the porous, brittle material becomes durable and elastic under pressure, the bricks are then put endwise on a *beton* bed, and set with hot tar. It is said that the rough usage which the pavement made of these bricks will stand is astonishing. A few years ago, in California, a pavement was laid of bricks, those that were soft-burned being selected, which were saturated with boiling coal tar. They were placed endwise on a bed of concrete, and the interstices filled with the hot tar, sand being scattered to the depth of about one-half (½) inch upon the pavement, and afterward swept off. And now we learn from an exchange that bricks impregnated with creosote or bitumen have been adopted for paving purposes in Nashville, Tenn., and with very satisfactory results. The wear is very uniform, as the softer and more porous bricks absorb more bitumen, which has the effect of hardening them, at the same time making them absolutely impervious, and thus protecting them from the disintegrating effect of frost. It is stated that pavement of this type, exposed for three and a half (3½) years to the wear of fairly heavy traffic, was, at the end of that period, found to be in excellent condition. The process of bitumenizing, however, rather more than doubles the cost of the brick.

A POLISH FOR WOOD.

The wooden parts of tools, such as the stocks of planes and handles of chisels, are often made to have a nice appearance by French polishing; but this adds nothing to their durability. A much better plan is to let them soak in linseed oil for a week, and rub with a new cloth for a few minutes every day for a week or two. This produces a beautiful surface, and has a solidifying effect on the wood.

TO CALCULATE THE NUMBER OF SHINGLES FOR A ROOF.

To calculate number of shingles for a roof, ascertain number of square feet, and multiply by four, if two inches to weather, 8 for 4½ inches; and 7 1-5 if 5 inches are exposed. The length of a rafter of one-third pitch is equal to three-fifths of width of building, adding projection.

VALUABLE FIGURES.

The following figures are worth remembering, as they will save a good deal of calculation and give approximately accurate results with a minimum of labor:

A cord of stone, three bushels of lime and a cubic yard of sand, will lay one hundred cubic feet of wall.

Five courses of brick will lay a foot in height on a chimney.

Nine bricks in a course will make a flue eight inches wide and twenty inches long, and eight bricks in a course will make a flue eight inches wide and sixteen inches long.

Eight bushels of good lime, sixteen bushels of sand and one bushel of hair, will make enough mortar to plaster one hundred square yards.

One-fifth more siding and flooring is needed than the number of square feet of surface to be covered, because of the lap in the siding and matching of the floor.

One thousand laths will cover seventy yards of surface, and eleven pounds of lath nails will nail them on.

One thousand shingles laid four inches to the weather, will cover one hundred square feet of surface, and five pounds of shingle nails will fasten them on.

FROSTED GLASS.

Verre Givre, or hoar frost glass, is an article now made in Paris, so called from the pattern upon it, which resembles the feathery forms traced by frost on the inside of the windows in cold weather. The process of making the glass is simple.

The surface is first ground, either by the sand blast or the ordinary method, and is then covered with a sort of varnish. On being dried, either in the sun or by artificial heat, the varnish contracts strongly, taking with it the particles of glass to which it adheres; and, as the contraction takes place along definite lines, the pattern produced by the removal of the particles of glass resembles very closely the branching crystals of frostwork.

A single coat gives a small, delicate effect, while a thick film, formed by putting on two, three or more coats, contracts so strongly as to produce a large and bold design. By using colored glass, a pattern in half-tint may be made on the color ed ground, and, after decorating white glass, the back may be silvered or gilded.

PERFECT MITERING.

BY OWEN B. MAGINNIS.

The many awkward ways in which so many woodworking mechanics endeavor to mark and cut in soft and hard wood moldings, and the botching results of their efforts, has induced the writer to give the following simple and successful methods which are perfect in their accuracy.

The different conditions which exist through the carelessness of those who precede him, when an operator commences to set in his molding, often cause him much trouble and loss of patience, as for instance, a molding being run standing on the little rebated lip or a raised molding being out of square, or an obtuse angle, instead of a little *under*, or an acute angle. This will of course necessitate, either the re-rebating of the molding by hand, or taking the arris of the corner of the panel sinkage as shown at *A*. Fig. 1. Then the molding

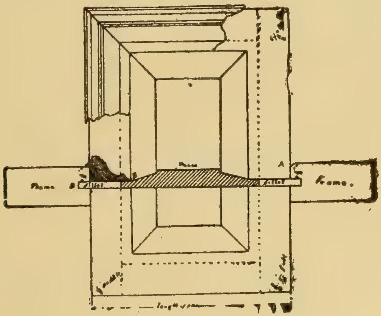


FIG. 1.

is often stuck too thin for sinkage, as will be clearly seen on the left hand side of the panel at *B*, and again the surface of the door, on account of the inequalities of the thickness of the pieces, especially on the back side, often varies as much as $\frac{1}{16}$ of an inch. This difficulty is easily overcome by the following sure process.

Take a small strip, and, placing the end of it down in the corner, mark the arrises with a sharp pocket knife. Measure these depths; in the case shown here they will be, for example, respectively, ½-inch, ½-inch, $\frac{1}{16}$-inch, full, ½-inch full, and ½-inch, scant. Having done this, make 4 strips, or saddles,

equal in width to the different depths of the sinkage, as ½-inch wide, ½—$\frac{1}{16}$ wide, and so on, each being about ⅜-inch thick and long enough to go into the miter box between the saw cuts.

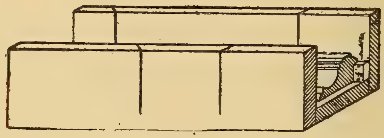


FIG. 2.

Place it in the box as represented at Fig. 2, with the lip of the molding resting on the saddle as it will rest on the door frame, at the miter and saw the left-hand end (say on the ½ scant saddle): To get the neat and exact length without gauging on the door. From the point where the saw crosses the saddle at Fig. 3, square across the bottom of the box with the pen-knife. These lines are the neat and exact lengths for either end, so if the thin edge — *B*, Figs. 1 and 3, of the molding, be marked at the opposite arris, holding the already mitered end close into its corners — and then this mark be placed at the asterisk or intersection, and the molding sawn on the saddle necessary for the opposite corner (say ½ full saddle), and so on all around the panel, it will, if cut out of one piece, perfectly utersect in its profile, the lip will come to a close joint on the frame, and the thin edge close to the panel. The dotted line in Fig. 3 shows how the molding should be held down in the box. The best way is to try a pair of pattern pieces as shown at Fig. 1 (on the necessary saddle), trying the patterns in each corner.

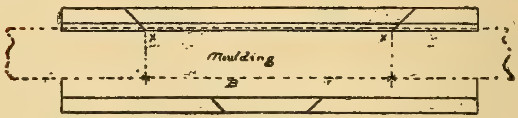


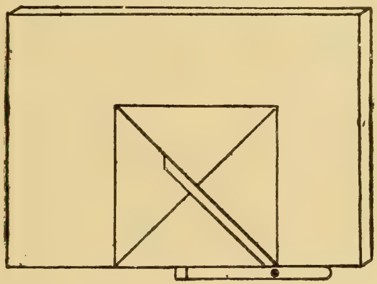
Fig. 3.

By this means it will be easy to find the exact saddle which will bring a good miter. Be sure they will come right before commencing to cut the molding all round. If it be too thick for the sinkage, of course it must be planed down on the back until it is a shaving thin, so that it will not strike the fillet, but press closely on the panel.

Great care should be exercised in cutting the miter box, as

perfect mitering is almost reliant on a good box, cut exactly on the angle of forty-five degrees. To set the level, lay out a square on a drawing-board about four inches wide. Join the opposite angles like at Fig. 4 (be certain it is exact to a hair, or the bevel will not reverse itself). Place the bevel onto the lines joining the angles as it lies on the board and mark the miter box by it. This is the only perfect way to miter and cut in raised moldings, and will always, without error, assure accuracy and good mitering.

Fig. 4.



Mitering flush molding or molding which does not rise above the surface of the frame is comparatively simple, and is usually done with a jack, except in the case of large molding. All that is necessary is to first miter the left-hand end and mark the right hand.

The handiest way is to commence at the right-hand corner next to you, and work to the farthest corner, and soon all round, returning to the one started from. Should the lengths, when placed in the panel before drawing down, be too long, take a rebate plane, shaving off until they be a snug, tight fit.

THE VENTILATION OF BUILDINGS.

Perhaps no single feature of modern architectural construction is likely to secure such immediate regard in the near future, and is already so conspicuously engaging the attention of the foremost men in the profession, as that of proper ventilation. Nor can it be denied that no feature is more important for health considerations in private homes, office

buildings and public institutions, than the securing of a steady supply of pure air and the coincident and corresponding removal of the vitiated air, so that the atmosphere in the rooms is, at all times, fresh and pure. The two points covered in the last sentence constitute what is known as, and is technically termed, "ventilation."

The expedients for obtaining a supply of fresh air to the room, so that there is a constant dilution and consequent bettering of the atmosphere, are comparatively simple. They merely imply that the air warmed by the hot-air furnace or steam coils in the cellar be taken from a place where it is pure (not, for instance, above a cesspool), that the ducts in cellar, through which the air travels, be air-tight (preferably so constructed of No. 22 or No. 24 galvanized iron, rather than of wood), and that some automatic means be adopted to regulate the temperature of the air supplied to the rooms, without shutting off such air supply. Or, when steam radiators are in rooms, that they be placed below windows, and air pass by means of proper orifices from outside through the radiators.

Furthermore, in large structures, a fan driven by electric or steam power is often instituted for forcing in a larger amount of fresh air than could be secured by the natural suction of the warmed air.

But the mere supply of warmed fresh air to the rooms is not enough. For note, if the air in the room has no escape, it does not take long, whatever the fresh air supply, before the vitiated air contaminates and makes foul the air as it enters the apartment. To open the windows is the remedy which the uninitiated at once suggest, and, in fact, in most houses this is the only palliative at hand.

It is, however, one of the first principles of ventilation, that the windows must not enter as an expedient. In a properly ventilated building the windows should never be open when people are in the rooms, at least in the winter months. For, opening the windows secures the admission of cold air in bulk, but does not remove the foul air, and more especially causes pneumonia-giving draughts, and chills the room, and in this way more damage is done than by even the presence itself of vitiated air in the rooms.

A warm or hot room does not necessarily signify an impure atmosphere; while we may have a room cold and the atmosphere still terribly impure. The unthinking never take this into account, and are apt to confuse the term warm with impure, and the term cold with pure atmosphere, as far as the rooms they are in are concerned.

The proper way to remove the vitiated air is by means **of vent-ducts**, or vertical flues leading from the rooms to the roof of the building. These flues should have an aggregate cross-sectional area at least equal to, and preferably about ten per cent. greater than, the cross-sectional area of the fresh air inlets; and should be situated on the opposite (preferably diagonally opposite) side of the room.

These vent-ducts should have openings controlled by registers, near the floor and near the ceilings of the rooms, but the two registers should not be opened at the same time. The cross-sectional area of the registers should be twenty-five per cent. more than that of the vent-ducts.

The bottom register is the one ordinarily to be used; for the heavy, vitiated air sinks to the floor, while the fresher, unpolluted air rises. When the people in the room are smoking profusely, it is better to close the bottom and open the top registers of the vent-ducts, for the smoke rises to the top, and is then more speedily removed.

These vent-ducts cause a gentle draught in the same way that a chimney of a steam boiler or hot-air furnace does. The temperature in the room being higher than that of the external air, the temperature in the vent-ducts is also higher, and consequently a draught or removal of the vitiated air is secured, the amount depending on the area and height of the duct, and the difference of temperature between the external air and the air in the room. This system is known as that of natural ventilation.

To make this removal of vitiated air still more rapid than is secured by the natural draught just mentioned and explained, one of several expedients may be adopted. An exhaust-fan, driven by steam or electric power, may be placed near the top of vent-duct, and the air exhausted from duct by means of this fan, thus increasing the fresh air supply through fresh air inlet. This is frequently adopted in public buildings, where the rooms are, at times, full of people. Or the temperature of the air in the vent-ducts, and consequently the drabght and the removal of vitiated air, may be increased by any of the following means:

1. Gas jets may be burned in the vent-flues near the bottom.

2. Steam risers, through which steam of high or low pressure circulates, may run through the vent-ducts.

3. Such steam risers may have a large coil near top **or** right above vent-flues proper.

For private homes and dwellings; natural ventil**ation** suffices. For public buildings and large halls. **either the fan**

or the steam system should be preferably adopted. The gas jets give out a comparatively little additional heat, but are inexpensive in first cost, and in running expense.

In a paper "On the Relative Economy of Ventilation by Heated Chimneys and Ventilation by Fans," read by Prof. Wm. P. Trowbridge, of the School of Mines, Columbia College, before the American Society of Mechanical Engineers, Prof. Trowbridge decides that in all cases of moderate ventilation of rooms or buildings, where, as a condition of health or comfort, the air must be heated before it enters the rooms, and spontaneous ventilation is produced by the passage of this heated air upward through vertical flues, such ventilation, if sufficient, is faultless as far as cost is concerned. He consideres this a condition of things which may be realized in most dwelling houses, and in many halls, school-rooms and public buildings, inlet and outlet flues of ample cross-section being provided, and the heated air being properly distributed.

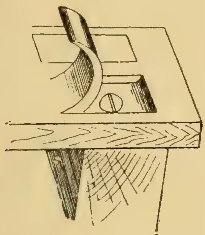
If, however, starting from this condition of things, a more active ventilation is demanded, the question of relative economy of fan and heated chimney is not so simple a problem. Prof. Trowbridge points out that ventilation by chimneys is disadvantageous under one point of view in any case, viz: the difficulty of accelerating the ventilation at will when larger quantities of air are needed in emergencies; while the fan or blower possesses the advantage in this respect, that by increasing the number of revolutions of the fan the head or pressure is increased. This latter fact makes the fan preferable for the ventilation of hospitals or public buildings of considerable magnitude, whenever, as is customary, the activity of the ventilation must be varied occasionally.

Where the power required is only a small fraction of a horse-power, as in ventilating single large rooms or small buildings, Prof. Trowbridge concludes it to be evident that as regards cost of fuel and the care and attention required, ventilation by heated chimneys is preferable, except, of course, for cases where a fan is driven by machinery employed for other purposes than ventilation, the cost of attendance chargeable to ventilation being then trifling and the fan evidently being more appropriate.

The construction of the building, of course, enters as an important factor, and often precludes the adoption of the exhaust-fan system. In large structures it is always important to take into account, and decide upon, the system of ventilation before the plans of the building proper are finished or finally adopted.

BURYING A SCREW HEAD OUT OF SIGHT.

To get the heads of nails and screws out of sight, where glue can be used without any objection, just raise up a chip with a thin paring chisel, as shown in the drawing, and then set the nail in solid. This "leaf" can be covered with a coating of glue and laid back again in place, where it must fit on all sides to perfection. A dead weight will hold everything in place till the glue dries, and a few moments with the scraper makes the job complete. It will add to the nicety of the work to draw lengthwise with the grain two deep cuts with a thin case-knife just the width of the chisel, and this keeps the sides of the chips from splitting. The chisel should be set at a steep angle at first till the proper depth is reached,



and then made to turn out a cut of even thickness until there is room to drive a nail. If too sharp a curve is given, the leaf is likely to break apart in being straightened out again. In blind nailing a narrow chip is taken with a tool made especially for this purpose, that lifts the cut just high enough to let in the nail on the slant, a set slightly concaved, being used to keep it from ever slipping off the head, and the upraised cut driven down again with the hammer.

HIP AND VALLEY ROOF FRAMING.

A simple way of laying out a hip or valley roof and finding the length of jack rafters, cuts and bevels, is shown in the accompanying sketch. The method followed is comparatively simple and easily understood.

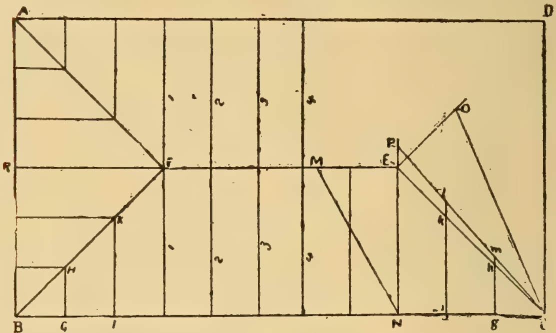
Lay down the plan of the building *A*, *B*, *C*, *D*, find the center line of the ridge *E F*, and show the plan of hips *A F* and *B F*, also the jacks *G H* and *I K*.

To find the length of the common or straight side rafters, lay off on the ridge line *E F* the height of the pitch *E M*. From the point *N*, which is the outside edge of the wall plate, join *N M*. This will give *N M* as the extreme length, on the upper edge, of the common rafter which is to stand over the seat *E N*.

In order to find the length of the hip rafters which will stand over the seats *C E* or *B F*, draw the line *O E* square with the line *E C*, and make *O E*=*M E* the height of the pitch. Join the point *C* with the point *O*, thus

obtained, which will give the length to the hip rafter on its upper edge.

The length of the jack rafters is generally obtained by direct measurement, but the following method will be found correct. Produce the line $N E$, and make $N P$ equal to the length of the common rafter, so that $N P = M N$, join $P C$, which will equal $C O$; produce the seat of the jack



rafters k i and g h, until they intersect $P C$ in l and m, and then i l and g m will be the correct lengths for the jack rafters.

In raising a roof of this description, it is usual to cut the ridge $E F$ and the common rafters which abut against it at each end as at $R F$. In placing them in position they are fastened plumb over their seats by braces, and the side rafters are placed each against its mate, as *1* against *1*, *2* against 2, *3* against *3*, and so on.

When all the side rafters are in position, the hips are inserted, and their accompanying jacks.

PAINTING AND VARNISHING FLOORS.

A French writer observes that painting floors with any color containing white lead is injurious, as it renders the wood soft and less capable of wear. Other paints without white lead, such as ochre, raw umber or sienna, are not injurious and can be used with advantage. Varnish made of drying lead salts is also said to be destructive, and it is reccommended that the borate of manganese should be used to dispose the varnish to dry. A recipe for a good floor var-

nish is given as follows: Take two pounds of pure white borate of manganese, finely powdered, and add it little by little to a saucepan containing ten pounds of linseed oil, which is to be well stirred and raised to a temperature of 360° Fahr. Heat 100 pounds of linseed oil in a boiler till ebullition takes place; then add to it the first liquid, increase the heat and allow it to boil for twenty minutes. Then remove from the fire and filter the solution through cotton cloth. The varnish is then ready for use, two coats of which may be used, with a final coat of shellac, if a brilliant polish is required.

A COLOSSAL STICK OF TIMBER.

A colosal stick of lumber from Puget Sound has been contributed to the Mechanics Exhibition at San Francisco. Its length is 151 feet, and it is twenty by twenty inches through. It is believed to be the longest piece of timber ever turned out of any saw mill.

A few years ago mechanics cared very little about winter work of any kind. They rather looked forward with pleasure to the prospects of a long rest. Things have been changing recently, and the tendency now is to secure all the winter work possible: One reason is, there are more building and loan associations, more insurance societies, more lodges and more organizations of one kind and another, all of which must be kept up. Besides, there is an increasing amount of work that has heretofore been done in summer. The cost of labor in a good many vocations is less in winter than it is in summer, owing to the small amount to be done and the greater number seeking it.

PLASTER FOR MOLDINGS.

Where walls and ceilings are to be molded whilst yet in a plastic state, some decorators are using a fibrous plaster, with the object of securing greater firmness and tenacity. The idea itself is not new, animal hair having formerly been intermixed with lime, but this is a new application. In England and France a fine wire netting is at times inserted between two courses of plaster, to afford greater firmness in holding picture frames. The tenacity of some of the old moldings in old New York houses, whilom aristocratic, is very remarkable, retaining as they do their original sharpness of outline.

THE SWEATING OF CHIMNEYS.

The sweating of chimneys is now believed to be due to condensation of the moisture in the air that is confined in a poorly ventilated chimney flue. The trouble, as our correspondent indicates, is chiefly to be found occurring in small chimneys, and in such chimneys whose flues start from the second or third story of a building. The sweating is the most copious when a fire is started in a place that has been for some time in disuse, or, in other words, when the flue is cold. The humidity of the air is a large factor in the phenomena of sweating. If the air be charged with moisture, the flue cold, and a fire newly kindled, the conditions are favorable for sweating. It is only under these favorable conditions that a well-ventilated chimney will begin to sweat, but the sweating will not continue. If sweating should continue in a chimney after a fire is fairly under way, it can be safely concluded that the chimney needs an opening near the ground to provide a better circulation of air within the flue. It may be, as our correspondent suggests, that rain may beat in and cause the same effect as sweating, especially where the rain has continued for several days together, and in that case a cowl, such as has been lately described in Building, in House and Stable Fittings," would cure the disease by excluding the rain; but such occurrences are exceedingly rare, and we have seen chimneys guilty of sweating that were provided with the most approved form of cowl, and the remedy applied has been to insert an air-brick at the base of the chimney to secure better ventilation, so as to lessen condensation, and the device has proved successful. Cowls prove useful only so far as they promote ventilation by increasing the circulation within the chimney flue. A cowl may be so improperly applied to a flue as to promote, instead of abolishing, sweating. The main point is to provide an ingress of air sufficient to tax the extractive capacity of the cowl that is used.

STRENGTH OF HORSES.

It is stated that, if one horse can draw a certain load over a level road on iron rails, it will take one and two-thirds horses to draw the same load on asphalt, three and one-third horses to draw it on the best Belgian block, five on the ordinary Belgian pavement, seven on good cobblestones, thirteen on bad cobblestones, twenty on an ordinary earth road, and forty on a sandy road.

SMOKY CHIMNEYS AND HOW TO CURE THEM.

A smoky chimney is a complaint we are often called upon to deal with, and the best way of building chimneys which should not smoke into the rooms, and of remedying existing chimneys which are liable to do so, is a matter of great importance to estate clerks of works. There are many small matters in building new chimneys which, together, may be a means of preventing them from smoking at the wrong end; but my intention at present is to deal only with the shaft or stack, or portion outside the roof, and my object is not to give ornamental elevations of chimney heads, which are unnecessary for the purpose of this article, but to explain a way of forming them which I have many times found to give relief to inveterate smokers. A common shaft, such a one as would be adapted for existing old cottages, is 2½ bricks or 1 ft. 10½ in. in width, and in my opinion none should be less than this, with a 9-inch earthenware flue-pipe built in solid; this I usually commence on the damp course, which should be just above the flashings of roof. As the area of the round pipe is smaller than the 14-inch by 9-inch brick flue on which it is placed, a quicker current of air or draught is thereby generated, and in windy weather a check is given to sudden down-draughts. Another advantage in a flue-lined stack is that there is no danger of the brickwork cracking when the soot in the flue is on fire, and which, owing to the scarcity of chimney-sweeps, is often the case in country places. Stoneware drain pipes, however, are quite unfit, as they are liable to split with the heat; but the tubes made of fire-clay or terra-cotta, only should be used. Another help is to keep the stack dry; a damp flue is generally a smoky one, and if a fire is lighted in the fire-place, say, of a disused bed-room, it is a common occurrence to see the smoke puff down violently and the chimney is said to have a down-draught, and by many people is assumed to be badly constructed, whereas, perhaps, it may be built in the best possible manner except that it will not keep out rain and damp. The rain may come through the sides of the stack, or it may come downward through the head; at any rate the chimney for some distance from the top is, in wet weather, cold and soppy. I roof the chimney top with plain tiles, with the object of protecting the head and permitting the rain to drop off at the eaves instead of running down the stack and making the flue cold, and the stack outwardly black and soot stained. I bed the tiles in cement, using copper nails driven into the latter through the pin holes—or a plain, cemented weather-

ing looks fairly well. But by forming the covering with tiles a good drip is obtained, which is not so readily done with cement. Another point is not to make the slope or pitch of a suitable angle, and this, in my opinion, should be about 45 degrees, as I find that inclination most effectual; when the wind strikes the slope it takes an upward direction, and, as a matter of course, carries the smoke with it.

Some time since a gentleman living by the seaside was much troubled with smoky chimneys, and asked me what was the best thing to do; I told him near about what I have just now written, and a short time afterward I received a letter (which I must confess somewhat scared me) saying he had decided to pull down his chimneys and rebuild them on my principle, and desired me to order for him two truck loads of George Jennings' flue pipes at once. This I did, and waited anxiously for the result; at last I was gratified by hearing "Chimneys are a great success," but it was summer time, and I was not so sure how they would act in cold, boisterous weather by the seaside, where every patented smoke-curer had apparently been tried by some one or other; but eventually I was glad to learn that they continued to draw well.

I have proved this system of chimney stack building to be good in a large number of cases; for instance, my office chimney is directly under the branches of a large tree, and the fire is on the hearth, yet I am never troubled with smoke.

For economizing heat in single houses or detached cottages, we all know it is the best plan to get the chimney on the inside, and not forming a portion of the outer walls, as in the latter case they are much more likely to smoke, and we also know that register grates, or grates with doors a few inches above the fire, generally make the fire draw; they not only draw the smoke, but a greater portion of the heat as well, and necessitate getting very close to the fire to obtain a portion of the heat going up the chimney. To my mind, there is nothing to equal a fire on the hearth, and wood, if you can get it, in preference to coals.

There is much might be said about set-offs in flues, and I know they are objected to as a rule, but I believe a chimney with one or two set-offs is all the better for it. I also believe chimney heads built in cement mortar true economy; the latter makes good work and looks well, long after chimney heads built with lime mortar, which soon show startling mortar joints and crumbly bricks. How often do we find old chimney heads want repointing, for the weather loosens the mortar and the birds carry it away.

The summary of my experience is briefly this:

1. Put a damp course to new chimneys, or insert one in old chimneys.

2. Line the chimneys with fine pipes above the damp course.

3. Roof the chimney tops carefully.

4. Don't forget a good projecting eaves-drip to the chimney-head.

4. Build the heads with cement mortar.

FACTS ABOUT FURNACES.

In February, 1881, the committee of hygiene of the Medical Society of Kings County rendered a report, which is published in full in the proceedings of that society, upon catarrh, and whether that disease was aggravated by residence in cities. The opinions of a large number of physicians of long experience were obtained, and their testimony showed "that, though climatic and city influences have much to do with the creation of catarrh, yet defective heating, lighting, airing, sunning and drainage of houses, with improper views as to air, clothing, bathing and exercise, are the main causes." Individual physicians laid special stress upon individual influences, as "dry and irritating air from villainous furnaces, increased furnace heat and artificial methods of living."

Furnace air *per se* is not so unwholesome, but it is the absence of ventilation which makes it so. If a furnace is of sufficient size to warm a building without opening every draft and heating the fire-pot red-hot, and if the fresh air supply is taken from a proper source and not from a damp area or unclean cellar; and, furthermore, if there are sufficient openings at the top of the house to allow the impure air which rises to that point to escape and thus cause a constant circulation of sufficiently warmed but not overheated air through the house, under these conditions a furnace is not objectionable.

Furnaces are often badly located. It is easier to force warm air through a furnace flue fifty feet away from the prevalent wind than ten feet in the opposite direction. Hence the furnace should be placed nearest the northern side of the building, or two should be provided. Hot-air flues should not be carried for any distance through cold cellars, halls or basements, as they will become chilled, and will not draw without being cased with some non-conducting material, as mineral wool.

Don't set a furnace in a pit, especially in a wet soil where water will collect after every rain storm, but stand it on brick arches, so as to raise it above the ground; also cement the pit. It is unfortunately very common to find such depressions filled with water; this causes rusting of the furnace itself and damp in the cellar. In very many houses occupied by persons of means, the furnaces are no longer used, but have been replaced by open fires. This is costly comfort, but it is a commendable plan, as it furnishes ample ventilation to the living rooms. It is desirable that one room should at least be thus supplied with a careful and sanitary fire.

Where fresh-air inlets are carried from the house drain to the front of a house at the yard level, they should not be located near to the cold-air supply, as there is a chance that during heavy states of the atmosphere a down-draft may be created, and the foul air sucked into the air box and thence upward into the house. Registers should never be placed at the floor level, as they will collect dust and sweepings, which are liable to take fire.

Furnaces with heavy castings heat slowly and are less easily cracked or warped, and they cool more slowly, so that the heat evolved is more uniform. It is well to retain the air close to the fire-pot, and thus keep it longer in contact with the fire-heating surface.

Water pans are often badly arranged so that they admit dust, and as they are seldom cleaned that may become offensive. They should always be supplied by a ball-cock so as to be automatic, rather than by a stop-cock which has to be opened by a servant, who may be neglectful.

Attempts have been made to filter the air before entering the furnace, but they usually fail. A screen of galvanized iron wire of 1-16 mesh will exclude most floating material from the air. The air supply is sometimes taken from the attic, but it is apt to be dusty and impure. Others take it from vestibules of halls or piazzas, which are not bad places.

STEAM vs. HOT-WATER HEATING.

Hot water as a heating agent is one of the oldest in use, and has a number of advantages in its favor. For mild climates it answers very well. For northern latitudes, however, and in countries such as Canada and most of our northern States, having long, severe winters, hot-water heating is not in general use on account of the following objections:

High First Cost—Hot water, as generally used, only gives off two-thirds the amount of heat per square foot of radiating surface which steam will give under similar circumstances. To get the same results as from steam it therefore requires about fifty per cent. more of radiators, and a corresponding increase of piping.

Added to the expense of this extra material is that of labor, which increases in the same proportion, thus making the entire first cost of hot water about one-third higher than steam.

Leakage—As all the pipes are continually full of water, any leakage will rapidly flood the house, causing trouble and damage. With steam, the flow-pipes contain no water whatever, and the return drip-pipes but very little, so that in event of a leakage the wate would be discovered and stopped long before it could do any damage.

No Way to Shut Off—We have never yet seen a hot water radiator which can be turned off and yet allow the water within it to flow back to the boiler; the construction of the radiator being such that all the water must circulate up and down between divisions connected alternately at the top and bottom.

When the radiator is turned off, these divisions still remain full of water which has no chance to run off. It is therefore necessary to keep all the radiators in the house running all the time, or else take the chances of their freezing and giving trouble if they are shut off. Now there are certain rooms in almost every house, such as guest-rooms, which are only occupied occasionally, and it would be a useless expense and inconvenience to keep them constantly warmed. The advantage of steam over hot water in this respect is evident. With steam you can shut off any radiator you please, and keep every room in your house at the exact temperature disired, without inconvenience or waste of heat.

Freezing and Bursting—It is a curious fact that hot water will cool down and freeze much quicker than ordinary water under the same circumstances. The first effect in boiling water is to drive off all its air, hence, becoming more solid and condensed, it is very susceptible to cold and will freeze very easily. If the fire in the boiler from any reason goes out, the water of course soon stops circulating, and in cold weather the pipes will rapidly freeze and burst.

Difficulty of Regulation.—In zero weather it is difficult to keep warm by hot water, unless there is a great amount of heating surface, and then in mild weather you are liable at any time to have too much heat. This is especially noticeable in any sudden change of temperature.

Hot water, being slow in acquiring heat and slow in parting with it, is consequently difficult to regulate with any degree of satisfaction.

This feature is seen in greenhouse heating particularly. When the sun is shining, on account of the great amount of natural heating glass surface, the temperature soon runs up above the normal, causing a necessity for opening the ventilators and so wasting the heat. And should the temperature once get down, it takes a long time to get it up again.

The advantage of steam in this case is apparent, as it is capable of being handled and regulated rapidly, and therefore is superior to any other method wherever an even and uniform temperature is desired either for a greenhouse or a dwelling.

Comparative Economy.—Careful experiments have recently been made by parties owning many greenhouses—some of which are warmed by steam and others by the most approved of hot-water heaters—for the purpose of accurately determining the relative cost of fuel in each case. They had nothing to gain by such experiments except the truth, as, with all florists, coal is a very heavy item and one of the principal expenses attending the running of a greenhouse.

Without entering into details, it has been demonstrated that greenhouses may be heated by steam on two-thirds the quantity of coal required for a hot-water apparatus. This fact has become so well established, that to-day steam is very rapidly taking the place of every other method for warming greenhouses.

The objections to hot water for this class of buildings is, moreover, much less than for residences, on nearly all the preceding five points. For instance, a leakage of a pipe can do no harm, as in a house, and there is, of course, no occasion to shut off any portion of the system, as is sometimes desired in a house.

Although the expense of a change from hot water to steam is heavy, yet the advantages secured are so great and apparent that it will not be long before hot water as a heating agent will be practically abandoned in every kind of building.

INTERESTING FACTS ABOUT ISINGLASS.

Isinglass consists of the dried swimming bladder of fishes. The bladders vary in shape, according to their origin, and they are prepared for the market in various ways. Some are simply dried while slightly distended, forming pipe isinglass. When there are natural openings in these tubes they are called pursers. When the swimming bladders are slit open, flattened, and dried, they are known as leaf isinglass. Other things being equal, the value of a sample is determined by the amount of impurities present. These impurities are ordinary dirt, mucus naturally present inside the bladder technically called grease, and blood stains. If the bladders, were hung up to dry with the orifice downward, the mucus could be drained off; but usually the fishermen fear the reduction in weight, and take care to retain all they can. It is necessary to insist on having the bladders slit up and rinsed clean as soon as they are removed from the fish. This would so much increase the value of the product that the extra labor would be very profitable. Blood stains cannot be removed without injuring the quality. If any process could be devised effectual for this purpose, a valuable discovery would be made.

The uses of isinglass are not very varied. The largest quantity is used by brewers and wine merchants for clarifying. This property is extraordinary, for gelatin, which seems chemically the same thing as isinglass, does not possess it.

For clarifying purposes the isinglass is " cut " or dissolved in acid, sulphurous acid being used by brewers, as it tends to preserve the beer. When reduced to the right consistence, a little is placed in each cask before sending it out for consumption.

There seems to be only six isinglass cutters in England, all being in London. The sorted isinglass is very hard and difficult to manipulate. It is soaked till it becomes a little pliable, and is then trimmed. Sometimes it is just pressed by hand on a board with a rounded surface ; at others it is run once between strong rollers to flatten it a little. The next process is that of rolling. Very hard steel rollers, powerful and accurately adjusted, are used. They are capable of exerting a pressure of 100 tons. Two are employed, the first to bring the isinglass to a uniform thickness, and the smaller ones, kept cool by a current of water running through them to reduce it to

little more than the thickness of writing paper. From the finer rollers it comes in a beautifully transparent ribbon, many yards to the pound, "shot" like watered silk in parallel lines about an inch broad. It is now hung up to dry in a separate room, the drying being an operation of considerable nicety. When sufficiently dried, it is stored till wanted for cutting, or it is sold as ribbon isinglass to all who prefer this form.

MODERN USES OF TIN.

The uses of tin have greatly increased during the last few centuries of our era. Salmon, in his splendid work on casting tin (1788), describes the methods of work, and mentions the objects manufactured from this metal. We see from the plates of his atlas that table services (spoons and forks) pitchers, jugs, candelabra, lamps, surgical instruments, chemical apparatus, boilers for dyeing scarlet, etc., were being put upon the market in the most varied forms of that epoch.

Griffith, between 1840 and 1850, perfected the manufacture of tin utensils in a single piece. This industry became especially developed in France from 1850 to 1860.

In 1860 America began manufacturing impermeable boxes, without soldering, from single pieces of metal.

To-day tin is being used in the manufacture of bronzes for guns, money and medals, and in the alloys used for making measures of capacity for liquids. Its unalterability in the air, and the harmlessness of its salts when they exist in small quantity, cause it to be employed in our day in the manufacture of culinary vessels and utensils. Advantage is taken of its malleability to form from it those thin sheets that are used as wrappers for chocolate, tea, etc.

In the various bronzes that it forms with copper, we have evidence of the influence that relative proportions of the two metals have upon the properties of the alloy. Thus gun bronze, which contains ten parts of tin to ninety of copper, is remarkable for tenacity. The bronze of tom-toms and bells, which differs from the last named only in its larger proportion of tin (twenty to eighty of copper) is, on the contrary, very brittle, although it fortunately possesses greater sonorousness than gun metal does. On still further increasing the proportion of tin to thirty-three parts per sixty-seven of copper, we obtain a white alloy capable of taking a polish that causes it to be used for the manufacture of telescope mirrors. Upon uniting with tin, copper loses its ductility. The alloys of these two metals increase in density through being hardened, as they do also by being hammered.

A mixture of twenty parts of tin with eighty of copper gives an alloy which is brittle at a bright red heat and when cold, but which is malleable at a dark red heat.

When alloyed with lead, the tin forms plumbers' solder. Associated with mercury, it gives the silvering of looking-glasses. Besides this, it enters into a host of fusible alloys or compositions, known under the general name of white metal. One of these alloys, composed of tin, antimony and copper, is very much used as a bushing for engine bearings. For this purpose the following are very good proportions: Tin, 100; antimony, 10; copper, 10. It is also alloyed with antimony alone, or with bismuth. It serves for tinning copper and iron kitchen utensils. To this effect the wrought-iron utensils are cleaned with sand and then wiped, and afterward immersed in a bath of molten tin, and finally rubbed with tow saturated with sal-ammoniac. Food cooked in tin vessels has a slight fishy taste, because it dissolves a little of the tin, just as food prepared in iron contracts a slight taste of ink.

Tin is used in enormous quantities also in the manufacture of tinplate. In order to prepare this, the sheet iron designed for the manufacture of it is cleansed by plunging into diluted sulphuric acid, which dissolves the pellicles of oxide. Then it is rubbed with sand and immersed in melted tallow, and afterward in a bath of tin covered with tallow. When taken out it is tinned, there having formed upon the surface of the sheet iron a true alloy of iron and tin covered with pure tin. Tin plate is as unalterable as tin itself, because the iron does not come into contact with the air at any point; but if, upon cutting it, we expose the iron, oxidation proceeds more rapidly than it would if the iron had not been tinned.

Upon washing the surface of the tinplate with a mixture of hydrochloric and nitric acids, we remove the superficial layer, and render visible the crystallized surface of the tin and iron alloy. We thus obtain what is called moire metallic or crystallized tinplate.

It now remains for us to say a few words about the new and important use of tin for the preparation of phosphor bronze.

In the melting of bronze the absorption of oxygen is very detrimental, the formation of an oxide of tin rendering the metal brittle. In former times an endeavor was made to prevent this oxidation by stirring the mass with wood, or by adding a little zinc to it; but for the last fifteen years greater success has been obtained by the addition of a little phosphorus This substance extraordinarily increases the compactness, toughness and elasticity of the product, and

gives it, in addition, a beautiful golden color. Guns, statues, ornaments and bearings are now cast from phosphor bronze with the greatest success.

Kunzel, of Dresden, has taken out a patent for an alloy composed one-half to three parts, by weight, of phosphorus, from four to fifteen of lead, from four to fifteen of tin, and for the rest, copper up to 100.

Schiller & Sewald, of Graupen, prepare two kinds of phosphor bronze; one with 2½ and the other 5 per cent. of phosphorus. The demand for this article is daily becoming more extensive.

The most important uses of tin are, in Asia, for tinning copper, and in Europe and America, for the manufacture of objects from tinplate. The manufacture of bronze and white metal likewise consumes a large quantity.

USES OF MICA.

The peculiar physical characteristics of mica, its resistance to heat, transparency, capacity of flexure and high electric resistance, adapt it to applications for which there does not appear to be any perfect substitute. Its use in windows, in the peep-holes on the furnaces used in metallurgical processes, as well as the ordinary use in stoves for domestic purposes, are examples of its adaptability to specific purposes which it does not seem to share with any other material. Its fitness for use in physical apparatus is represented by its application for the vanes on the Coulomb meter, recently invented by Prof. George Forbes, F. R. S. For electrical purposes mica has proved useful, acting as an insulator between the segments of commutators of dynamos and safety fuses in lighting circuits, also as the base part of switches handling heavy currents, to obviate the dangers of ignition by the arc formed when the switch is changed. For this latter purpose it shares the field with sheets of slate. Both of these uses were first suggested a number of years ago by an insurance expert in America in the course of regulations governing the safe installation of electric-light plants. As a lubricator, mica answers a very peculiar purpose for classes of heavy bearing, where the powdered mica serves a useful office in keeping the surface separate, thereby permitting the free ingress of oil. It is used in roof-covering mixtures in a powdered condition in combination with coal tar, ground steatite and other materials, its foliated structure tending to bond the material together. Not affected by ordinary chemicals which are corrosive to many other substances, it has

been applied in the valves to sensitive automatic sprinklers, where a sheet of mica placed over a leather disk has proved to be non-corrosive, and without possibility of adhering to the seat, while the leather packing rendered the whole sufficiently elastic to provide a tight joint.

IMPROVED PROCESS OF TINNING.

An improved process of coating metals with tin, by Borthel and Holler, of Hamburg, is said (by a metropolitan contemporary) to possess the advantage of preventing, or at least delaying, oxidation. The process can be employed with special advantage for tinning cast-iron cooking utensils, household and other implements of cast iron, as the employment of poisonous enamel is avoided and a much higher degree of polish attained. The process can also be employed for protecting architectural or other iron decorations from rusting by the coating of tin or other metal, without detriment to the sharpness of the form, as is the case with the customary oil or bronze paints. In order to produce a perfectly even coating of tin on cast iron, the same is first provided with a thin coating of chemically pure iron, regardless of the form of casting. This coating is produced in galvanic manner in a bath composed as follows: Six hundred grammes of sulphate of iron, $FeSO_4$, are dissolved in five liters of water, to which add a solution of about 2,400 grammes of carbonate of soda, Na_2CO_3, in five liters of water. The precipitate of ferro-carbonate ($FeCo_3$) resulting is dissolved in small quantities in so much concentrated sulphuric acid until the fluid has a green color. The bath is then rendered aqueous by adding about twenty liters of water. Blue litmus paper dipped in the bath must assume a deep claret color, and red litmus paper remains unchanged.

The objects to be provided with a coating of chemically pure iron are placed in the bath opposite to the abode of cast or wrought iron or iron ore, and both parts connected to the corresponding poles of a dynamo machine, electric battery, or other appropriate source of electricity. In a very short time the objects placed in the bath are covered with a coating of iron, the thickness of which depended on the duration of the action of the bath or the strength of electric current. The coated objects are then well rinsed in clear water, dried, then painted with, or immersed in, a solution of ammonia in chloride of zinc alone, and then immersed in a vessel containing molten tin The tin adheres with great tenacity to the prepared surface, and the surplus of tin can be readily removed

by a brush, or any other manner. If the object to be tinned is of such size, or so complicated in form, that it cannot be readily immersed in molten tin, it can be placed in a galvanic tin bath, which can be readily made in any desired size, and be provided with a layer of tin of desired thickness, which, after having been painted either with a solution of chloride of zinc or ammonia in chloride of zinc, can be heated to such a degree that the tin is equally melted on the object.

In like manner objects cast or made of lead or other readily melting metal, which would lose their form by melting when immersed in molten tin, are, previous to tinning, provided with a coating of pure iron, and are then provided with a coating of tin in a galvanic bath, as mentioned above, without being subjected to heat for melting the layer of tin deposited on the same. With objects of wrought or rolled iron, or which do not require the before described treatment —*id est*, the production of a coating of chemically pure iron — it will be sufficient to carefully clean the same and paint them with a solution of ammonia or chloride of zinc or a concentrated solution of chloride of zinc. This tinning process combines the advantage of simple manipulation and the great durability of the coating with cheapness of manufacture, which is partially attained in the saving of tin.

SOLDERING.

The term soldering is generally applied when fusible alloys of lead and tin are employed for uniting metals. When hard metals which melt only above a red heat, such as copper, brass or silver, are used, the term brazing is sometimes used. Hard-soldering is the art of soldering or uniting two metals or two pieces of the same metal together by means of a solder that is almost as hard and infusible as the metals to be united. In some cases the metals to be united are heated, and their surface united without solder by fluxing the surfaces of the metals. This process is then termed burning together. Some of the hard-soldering processes are often termed brazing. Both brazing and hard-soldering is usually done in the open fire on the brazier's hearth. A soldered joint is more perfect and more tenacious as the point of the fusion of the solder rises. Thus, tin, which greatly increases the fusibility of its alloys, should not be used for solders, except when a very easy-running solder is wanted. Solders made with tin are not so malleable and tenacious as those prepared without it. The Egyptians soldered with lead as long ago as B. C. 1490, the time of Moses.

Pliny refers to the art, and says it requires the addition of tin to use as a solder. The tin came mainly from the Cassiterides (Cornwall). Plumbers use solder composed of two parts of lead and one of tin, and a very slight variation in the quantities makes a very considerable difference in the working and also in the soundness of the joint. If a slight excess over the above proportion of lead is used, the solder is more difficult to work, and the joint when made frequently leaks, the water passing through the small cellules or pores in the metal, and the joint is then said to "sweat." If an excess of tin is used, the solder melts too easily, and considerable difficulty is found in keeping it on the joint, and it cools so suddenly that the joints always look rough and ragged at the ends. They sometimes require trimming up to make them look better; this solder also keeps running, and then congealing, in such a way as to be difficult to keep it at a workable heat Small portions of the metal also keep sticking to the cloth used for molding (technically called wiping) the joint or seam as the case may be.

Plumbers' solder, with the above proportions, on being melted, and then allowed to cool, will generally exhibit several bright spots on its surface, due to the two metals partly separating. These bright spots are generally a very sure guide as to the proper quantities of each metal used. If none are seen, it is too coarse; and if too many are seen, it contains too much tin and is said to be too fine. If the spots are small the metal may not be good, although it may have beyond its proper quantity of tin; but if the spots are about the size of a threepenny piece the solder very rarely fails to work well. In uniting tin, copper, brass, etc., with any of the soft solders a copper soldering-bit is generally used. This tool and the manner of using it are well known. In many cases the work may be done more neatly without the soldering-bit by filing or turning the joints so that they fit closely, moistening them with the soldering fluid described hereafter, placing a piece of smooth tin foil between them, tying them together with binding wire, and heating the whole in a lamp or fire till the tin foil melts. Pieces of brass are often joined in this way so that the joints are invisible With good soft solder almost any work may be done over a spirit lamp, or even a candle, without the use of a soldering-bit. Advantage may be taken of the varying degrees of fusibility of solders to make several joints in the same piece of work. Thus, if the first joint has been made with the fine tinners' solder, there would be no danger of melting it in making a joint near it with bismuth solder. The fusibil-

ity of soft solder is increased by adding bismuth to the composition. An alloy of lead 4 parts, tin 4 parts, and bismuth 1 part, is easily melted; but this alloy may itself be soldered with an alloy of lead 2 parts, bismuth 2 parts, and tin 1 part. By adding mercury a still more fusible solder can be made. Equal parts of lead, bismuth and mercury, with two parts of tin, will make a composition which melts at 122 degrees Fahr.; or an alloy of tin 5 parts, lead 3 parts, and bismuth 3 parts, will melt in boiling water. In melting these solders melt the least fusible metal first in an iron ladle, then add the others in accordance with their infusibility. It is convenient—and in fact, often necessary—to have solders which will melt at different degrees of temperature, to avoid the risk of spoiling the work by subjecting it to too great a heat, when, with a little easy-flowing solder, there would be no danger.

POINTS ON SOLDERING.

For tinning soldering coppers nothing is better than a soft-burned brick to contain the tin and solder. Dig a cavity on the side two or three inches long, and wide enough to receive the soldering tool. Melt some solder in the cavity thus formed, and throw in some pieces of sal-ammoniac and rosin. See that the copper bits are hot enough to melt solder; a great heat will not tin as well as a low one. Rub the tool on the brick, melting the solder, ammoniac and rosin. The brick scours the copper bright, and the flux causes the solder to adhere very easily. One of the worst things ever attempted is to solder a dirty job with a dirty, untinned copper.

See that the surfaces to be soldered are clean. If not, make them so by filing or scraping; then protect the surfaces from oxidation by an application of flux or muriatic acid in which zinc has been dissolved. Have the soldering copper hot. Hold it two inches from your face, and the right degree of heat will soon be learned. When all of these conditions exist, the melted solder will flow along the seam with the greatest ease, leaving a smooth, well-finished surface behind it.

To do work in the best manner and the easiest, a flux should be provided for each metal to be soldered. The hydrochloric (muriatic) acid and zinc flux is worthless when rust is to be avoided, for in some cases the acid continues to act after the soldering is done, and in a few months may eat far enough to separate the solder from the work. In this case, of course, the joint falls apart.

In soldering zinc some use muriatic acid diluted with water for a flux, and the rusting action is to be feared in this instance, but may be lessened by adding soda carbonate (washing soda) to the acid. There are few pieces that cannot be soldered without the use of an acid flux, and rosin will do nearly as well if a little oil be added, or if the soldering copper be dipped in acid and then into oil before applying it to the seam with rosin on it.

Sal-ammoniac is the proper flux for copper, and this agent works well with tin, but it is not necessary, for rosin is all that is needed. Lead is perfectly fluxed by tallow (the plumbers call it "touch"), but may be soldered witb either of the other fluxes.

NEW METHOD OF BRONZING IRON.

The following method is successful in producing a bronze-like surface which practically prevents rust. All the methods as yet known for producing a bronze-like surface, by rubbing over the surface of the iron an acid solution of copper or an iron solution, letting it dry in the air, brushing off the rust produced in this way, and an abundant repetition of this method, give a more or less reddish-brown crust or rust on the iron body. Objects formed of iron can easily be covered with copper or brass by dipping them in the requisite solution, or by submitting them to the galvanic method. The surface so prepared, however, peels off in a short time, by exposure to moist air in particular. By the method given below it is possible to cover iron objects, especially such as have an artistic aim, with a fine bronze-like surface; it resists pretty satisfactorily the influence of moisture, and one is, moreover, enabled to apply it to any object with great ease. The clean, polished objects are to be exposed to the action of the vapors of a heated mixture of hydrochloric acid and nitric acid, in equal portions, for from two to five minutes; they are not to be shifted, and the temperature may range from 300° to 350° C. The heating is continued so long that the bronze-like surface is well developed on the surface of the objects. After the objects have cooled they should be well rubbed down with vaseline and again heated until the vaseline begins to decompose. When again cold they should be a second time treated with vaseline in the same way. If the vapor of a mixture of the two concentrated acids is allowed to act on an iron object in this manner, a light reddish-brown tone is developed. If some acetic acid be mixed with the two acids, and the vapor of all the acids together be

allowed to act on the metallic surface, a fine bronze yellow color can be obtained. By using different mixtures of these acids every tint, from a dull red-brown to a light brown, and from a dull brownish yellow to light brown yellow, can be produced on the surface of the iron. In this way some T-rods for iron boxes were covered with a bronze-like surface, and at the end of ten months, although exposed during the whole time to the action of the acid fumes of a laboratory, they had undergone no trace of any change.

MANUFACTURE OF RUSSIAN SHEET IRON.

There appears to be much misunderstanding in reference to the manufacture of sheet iron in Russia, and questions are frequently asked the writer: "What are the secrets connected with it?" "How is it made?" "Could admission be obtained to the iron works in the Urals, where the iron is made?" It is difficult to understand why such questions should be asked by persons versed in the literature of iron and steel, for Dr. Percy wrote a very excellent and accurate monograph on the subject a number of years ago.

Not having had the opportunity of personally visiting the Russian iron works in the Urals, Dr. Percy's paper was compiled from data furnished him by a number of persons who had actually visited these sheet iron works. Since it has been my good fortune to have the opportunity of seeing some of these works in the Urals, but a short time ago, I will, at the risk of telling an old story, briefly describe the process of manufacture as I saw it.

The ores used for the manufacture of this iron are mostly from the celebrated mines of Maloblagodatj, and average about the following chemical composition: Metallic iron, 60 per cent.; silica, 5 per cent.; phosphorus from 0.15 to 0.06 per cent. The ore is generally smelted into charcoal pig iron, and then converted into malleable iron by puddling or by a Franche-Comte hearth. Frequently, however, the malleable iron is made directly from the ore to various kinds of bloomaries.

The blooms or billets thus obtained are rolled into bars 6 inches wide, ¼ inch thick and 30 inches in length. These bars are assorted, the inferior ones "piled" and re-rolled, while the others are carefully heated to redness and cross-rolled into sheets about thirty inches square, requiring from eight to ten passes through the rolls. These sheets are twice again heated to redness, and rolled in sets of three each, care being taken that every sheet before being passed through the

rolls is brushed off with a wet broom made of fir, and at the same time that powdered charcoal is dextrously sprinkled between the sheets. Ten passes are thus made, and the resulting sheets trimmed to a standard size of twenty-five to fifty-six inches. After being sorted and the defective ones thrown out, each sheet is wetted with water, dusted with charcoal powder and dried. They are then made into packets containing from sixty to one hundred, and bound up with waste sheets.

The packets are placed one at a time, with a log of wood at each of the four sides, in a nearly air-tight chamber, and carefully annealed for five or six hours. When this has been completed the packet is removed and hammered with a trip-hammer weighing about a ton, the area of its striking surface being about six to fourteen inches. The face of the hammer is made of this somewhat unusual shape in order to secure a wavy appearance on the surface of the packet. After the packet has received ninety blows, equally distributed over its surface, it is reheated and the hammering repeated in the same manner. Sometime after the first hammering the packet is broken and the sheets wetted with a mop, to harden the surface. After the second hammering the packet is broken, the sheets examined, to ascertain if any are welded together, and completely finished cold sheets are placed alternately between those of the packet, thus making a large packet of from 140 to 200 sheets. It is supposed that the interposition of these cold sheets produces the peculiar greenish color that the finished sheets possess on cooling.

This large packet is then given what is known as the finishing or polishing hammering. For this purpose the trip-hammer used has a larger face than the others, having an area of about 17 to 21 inches. When the hammering has been properly done the packet has received 60 blows, equally distributed, and the sheets should have a perfectly smooth, mirror-like surface. The packet is now broken before cooling, each sheet cleaned with a wet fir broom to remove the remaining charcoal powder, carefully inspected, and the good sheets stood on their edges in vertical racks, to cool. These sheets are trimmed to regulation size (28 by 56 inches) and assorted into Nos. 1, 2 and 3, according to their appearance, and again assorted according to weight, which varies from 10 to 12 lbs. per sheet. The quality varies according to color and freedom from flaws or spots. A first-class sheet must be without the slightest flaw, and have a peculiar metallic gray color, and on bending a number of times with the fingers, very little or no scale is separated, as in the case of

ordinary sheet iron. The peculiar property of Russian sheet iron is the beautiful polished coating of oxides ("glanz") which it possesses. If there is any secret in the process, it probably lies in the "trick" of giving this polish. As far as I was able to judge, from personal observation and conversation with the Russian iron masters, the excellence of this sheet iron appeared to be due to no secret, but to a variety of conditions peculiar to and nearly always present in the Russian iron works of the Urals. Besides the few particulars already noted in the above description of this process, it should be borne in mind that the iron ores of the Urals are particularly pure, and that the fuel used is exclusively charcoal and wood. Another and equally important consideration lies in the fact that this same process of manufacturing sheet iron has been carried on in the Urals for the last hundred years. As a consequence, the workmen have acquired a peculiar skill, the want of which has made attempts to manufacture equally as good iron outside of Russia generally unsuccessful. It is difficult to understand what effect the use of charcoal powder between the sheets, as they are rolled and hammered, has upon the quality. It is equally as difficult to understand the effect of the interposition of the cold-finished sheets upon the production of the polished coating of oxide. The Russian iron-masters seem to attribute the excellence of their product more to this peculiar treatment than to any other cause. One thing is quite certain, there is no secret about the process, and if the Russian sheet iron is so much superior to any other, it is due to the combination of causes already indicated.

THE LARGEST ELECTRIC LIGHT IN THE WORLD.

The largest electric light in the world is on St. Catharine's Point lighthouse, Isle of Wight. Some idea of the power of this light will be conveyed when it is known that the carbons employed in electric arc lamps commonly used for street lighting are about ⅜ inch in thickness, while these have a diameter of nearly 2½ inches.

There are two dynamos, and if both worked in conjunction it is computed that the concentrated light from the lantern would equal six millions of candles. The induction arrangement of each machine consists of sixty permanent magnets, and each magnet is made up of eight steel plates. The armature, 2 ft. 6 in. in diameter, is composed of five rings with twenty-four bobbins in each, arranged in groups of four in tension and six in quantity.

LUMBER MEASUREMENT TABLE.

LENGTH		LENGTH		LENGTH		LENGTH		LENGTH		LENGTH	
2x4		2x6		2x8		2x10		3x6		3x8	
12	8	12	12	12	16	12	20	12	18	12	24
14	9	14	14	14	19	14	23	14	21	14	28
16	11	16	16	16	21	16	27	16	24	16	32
18	12	18	18	18	24	18	30	18	27	18	36
20	13	20	20	20	27	20	33	20	30	20	40
22	15	22	22	22	29	22	37	22	33	22	44
24	16	24	24	24	32	24	40	24	36	24	48
26	17	26	26	26	35	26	43	26	39	26	52
3x10		3x12		4x4		4x6		4x8		6x6	
12	30	12	36	12	16	12	24	12	32	12	36
14	35	14	42	14	19	14	28	14	37	14	42
16	40	16	48	16	21	16	32	16	43	16	48
18	45	18	54	18	24	18	36	18	48	18	54
20	50	20	60	20	27	20	40	20	53	20	60
22	55	22	66	22	29	22	44	22	59	22	66
24	60	24	72	24	32	24	48	24	64	24	72
26	65	26	78	26	35	26	52	26	69	26	78
6x8		8x8		8x10		10x10		10x12		12x12	
12	48	12	64	12	80	12	100	12	120	12	144
14	56	14	75	14	93	14	117	14	140	14	168
16	64	16	85	16	107	16	133	16	160	16	192
18	72	18	96	18	120	18	150	18	180	18	216
20	80	20	107	20	133	20	167	20	200	20	240
22	88	22	117	22	147	22	183	22	220	22	264
24	96	24	128	24	160	24	200	24	240	24	288
26	104	26	139	26	173	26	217	26	260	26	312

A blast at 800 degrees temperature will ignite charcoal; 900 degrees will ignite coke, and 1,300 degrees will ignite anthracite.

THE DYNAMO.

HOW MADE AND HOW USED.

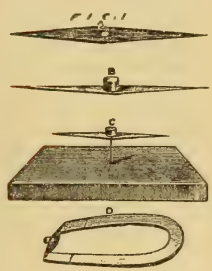
The interest awakened in machines for the generation of current electricity, consequent upon the demand for electric lighting and transmission of power, has induced many amateurs to turn their energies to the construction of small dynamos, such as might replace a battery of eight or ten cells, without the disagreeable features of changing acids, cleaning plates, etc. Such efforts have not generally met with success, owing to the fact that no work of a practical nature has yet appeared in which the construction of the dynamo is fully explained. When the principles which control the manufacture of such machines is understood, dynamos can be constructed with as much ease and certainty as induction coils.

§ 1. *What a Dynamo is.*—As understood at present, the dynamo-electric machine may be defined as a machine whereby energy (motion) is converted into electricty by the aid of the permanent magnetism present in certain iron portions: which electricity is caused to react on the iron and so heighten its magnetism; and this increased magnetism in its turn gives rise to more powerful electrical effects, and so on, until a limit is reached, depending partly on the velocity of the motion, partly upon the relative apportionments of the size and quality of the wire and iron employed in its construction, and partly on the resistance throughout the circuit. Although this principle was fully understood, and described by Soren Hjorth, of Copenhagen, in his patents, dated October, 1854, and April, 1855, yet the name "dynamo" (from *dynamis*, Gr., *force*) does not appear to have been used in this connection until Dr. Werner Siemens employed it in a communication to the Berlin Academy, January 17, 1867.

§ 2. *Faraday's Discovery.*—The closeness of the relationship between the phenomena which we call *electricity* and *magnetism* had struck many philosophers of the eighteenth century. Oersted, of Copenhagen, in 1819, was the first to prove, by a series of masterly experiments, the magnetic properties of current electricity; Ampère and Arago, in France, and Sir Humphry Davy in England, then distinguished themselves by their zeal and activity in this research; but the keystone of the arch was laid when Faraday, in November, 1831, showed that it was possible to call forth electric currents by means of a magnet. In order that the

reader should have an intelligent knowledge of the principles which underlie the construction of the dynamo, it would be well for him to repeat some of the experiments about to be described, more especially as they are easy of performance and trifling in cost.

The first thing required will be a *galvanometer*, an instrument for indicating the presence of current electricity (and in some cases to measure its quantity). To make this, a piece of spring steel, 2 inches long and ⅛ of an inch in width, is "softened" by heating the middle portion over a gas jet or other flame, until red hot, then allow to cool *gradually*. By laying this across a knife blade the exact center is found and *marked*. By means of a screw-drill a hole about $\frac{3}{32}$ of an inch diameter clear through the center of this steel "needle," as it is called, is bored. By filing from the center toward the side the needle is brought to the shape of a lozenge, as seen at Fig. 1, A. Holding this needle by means of a piece of copper wire passed through the hole, it is heated to dull redness over a flame and plunged into cold water to restore its temper. A piece of brass rod, ⅛ of an inch in diameter, and about ⅛ of an inch long, is now soldered centrally, just over the hole. This is easily done by cleaning the needle with a bit of sandpaper, specially round the hole, cleaning also the little piece of brass rod, on its end, then putting a little piece (as big as a grain of mustard-seed) of plumbers' solder just over the hole bored in the needle. Holding the needle with a pair of forceps (a little rosin powder having been previously applied round about the hole) over the flame of a spirit-lamp or gas-burner, will cause the solder to melt and adhere to the steel. The piece of brass is now taken up with another pair of forceps, and laid (flat side downward) as centrally as possible over the hole. Keeping the needle still over the flame, the solder will also flow round the brass and adhere to it, making a firm junction, when it may be removed from the flame, and placed *at once* on a cold metal or stone surface. It should now



present the appearance shown at Fig. 1, B. Any solder which may have exuded from between the brass and steel should be filed away. Using the same bit in the screw-drill that was employed originally to bore the hole through the steel, a conical hole, reaching nearly but not quite to the opposite surface of the brass piece, is drilled from the hole in the steel. This serves as a pivot on which to poise the needle. A trial may now be made to find whether the needle is fairly centered; but no attempt need be made *yet* to balance it if not true. Having cut off the head of a fine-pointed pin, drive it, blunt end downward, into the center of a little slab of well-seasoned pine 3 inches by 3 inches by ½ an inch, leaving not less than ¾ of an inch protruding. On the point poise the needle, and *mark* with a pencil the end which hangs (if either does). Fig. 1, C, will show what is meant. The needle must now be *magnetized* by being allowed to remain for some time (twenty minutes or half an hour) across, and in contact with the poles of a horse-shoe magnet, care being taken that having once placed the needle in one position it should not be reversed, as its polarity would be reversed if this were done; and since in our latitude the *north-seeking pole of a freely suspended needle hangs downward*, if the needle, when tried previous to magnetizing, had one end *heavier* than the other, *that* end must be placed against the north pole of the horse-shoe magnet, by which means it will acquire south-seeking polarity, and consequently neutralize to a certain extent the inclination of the poised needle. After magnetization it should be again poised, any deviation from the horizontal line noted and corrected by cautiously filing the needle on one of its flat sides, at its heavier extremity, with a fine file, until perfect equilibrium is obtained. Fig. 1, D, illustrates the position in which the needle should be placed with relation to the magnet during magnetization. When the needle has been well balanced it ought to turn very freely on its pivot, making several free swings, but finally taking up a position pointing *north* and *south*. It should also show decided polarity when tested with a magnet; that is to say, one extremity should be strongly *attracted*, and the other just as *strongly* repelled on the approach of the north pole of a horse-shoe or bar magnet. When all these conditions have been satisfied, it will be well to mark with a pencil the letter N on the extremity of the needle, which is *repelled* by the north seeking (or marked) end of the magnet. This extrem-

ity will be the *north-seeking end* of the needle, and is generally (though inaccurately) called its *north pole*.

§ 3. We have now succeeded in making and poising a magnetic needle. In so doing we have learned two important facts: (*a*) that *steel* becomes permanently magnetic when placed in proximity to a magnet; (*b*) that each pole of the new magnet thus formed evinces a polarity of opposite kind to that possessed by the pole of the original magnet which induced its magnetic condition; in other words, the *north* pole of the original magnet induces *south* polarity in that portion of the steel nearest to it, while the *south* pole induces *north* polarity.

Our next step is to surround the needle with a coil of insulated copper wire. To this end a piece of wood 2½ inches wide by 1½ inches thick, and of convenient length to hold in the hand, is prepared as a form, the edges being slightly rounded to admit of the wire being slipped off; this is then wound with about ten feet of No. 30 silk-covered copper wire, as shown at Fig. 2, A, leaving about three inches of wire projecting at each extremity.

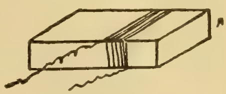


Fig 2. A

The four corners of the rectangle thus formed should be bound with silk, so as to prevent uncoiling when the rectangle is drawn off the wooden form. The coil, on removal from the form, should present the appearance shown at B, in which the ends of the silk used to tie the corners are purposely exaggerated in length, the better to show their position.

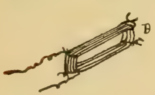


Fig 2 B

The center of the coil being found, the wires forming one of the flat sides are slightly parted by means of a blunt pin (care being taken not to abrade the silken covering), and the coil passed over the pin-point fastened in the center of the little baseboard above described (§ 2), and attached thereto with a little dab of hot sealing-wax, or, better still, with good elastic cement. The needle is then replaced, and tried, to see whether it oscillates freely without catching at any point in the coil. The two free ends of the wire are now to be denuded of their silk covering, cleaned with a bit of sand or glass paper, and attached to two small binding screws (those known as telephone binding-screws, and sold at most elec-

tricians' at 50 cents per dozen, will do admirably), inserted one at each corner of the base-board. The galvanometer or *multiplier* is now complete, and should appear as figured at C. When all is in position,

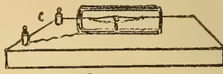


Fig. 2. C.

note from which binding-screw starts the wire which goes *over* the needle. Mark this binding-screw by writing "over" near it. The galvanometer is used to detect the presence of current electricity by causing any such current to pass through the coils of the instrument. For this purpose the two opposite extremities of any circuit, through which it is supposed a current is flowing, are each connected to one of the binding-screws. If a current passes, the needle (which previously must be made to lie parallel with the coil, by turning the baseboard round until the coil points north and south, like the needle) will immediately start out from its position of parallelism with the coil, and take up a position which will approach nearer to right angles with the coil, in proportion as the current is stronger. To test whether the galvanometer just made be fairly delicate, attach a piece of copper wire about $\frac{1}{32}$ of an inch thick and six inches long to one of the binding-screws; to the other attach a similar piece of iron wire. Now bring the free ends of the wire (by bending) within ⅛ of an inch of each other. Turn the baseboard round until the north end of the needle points between the two binding-screws, perfectly parallel to the coil. Put a single drop of vinegar on a little piece of glass, and bring it under the two ends of the wires, which must be lowered until they are both *in* the drop of vinegar, but do not touch each other. By the action of the vinegar on the two metals, an electrical disturbance is set up, which produces a so-called "current" which starts from the iron; passes through the vinegar, along the copper wire, through the coils of the galvanometer, and back again into the iron, this action being continuous as long as the vinegar acts on the iron. Simultaneously with this, the needle is seen to deflect from the line of the coil, and if our galvanometer is a success, it should stand out at least 20° from the central line of the coil. Faraday's great discovery, on which all dynamos are based, consisted in proving that a magnet could be caused to excite a current, similar to that produced by the action of acids on

FIG. 3

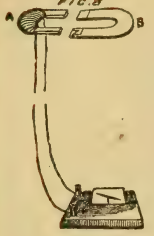
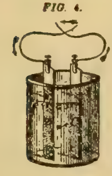


FIG. 4.



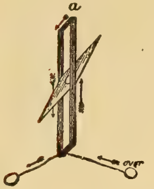
metals. We can now repeat his experiment with the aid of our galvanometer. Let A, Fig. 3, be a rod of ½ inch soft iron, about 6 inches long, bent to the shape of the letter U, and wound round its central portion with about 100 feet of No. 24 cotton-covered copper wire, the two ends of which (about a yard each end) having been stripped of their covering, must be attached to the binding-screws of the galvanometer. If a good horse-shoe magnet, B, be placed in contact with the two legs of the coiled U, this latter being kept motionless, while the magnet is alternately approached to and separated from it, it will be found that the needle of the galvanometer is powerfully affected, first in one sense and then in the other, according to whether we *make*, or *break* contact with the U, or *armature*, as it is called. We shall also find that, although the most powerful effects are noticed when actual contact and actual separation take place, yet currents are also produced on approaching or removing the magnet to or from a distance. In other words, *motion in the field of a magnet gives rise to electricity.* If we study the effects thus obtained, we shall find that they differ in some points very markedly from those obtained by the action of acids on metals (voltaic electricity—galvanism), inasmuch as first, the action is *not* continuous; secondly, it is contrary in direction when contact is *made* to what it is when it is *broken*.

§ 4. The student will do well to compare the effects produced on the galvanometer by the battery current, and by the current obtained from the magnet. Any single cell will do for this purpose; and in order to have an intelligent perception of what takes place, the student must bear in mind, that *in* the battery itself, the electricity (undulatory movement of the molecules) passes from the zinc to the negative plate (be it copper, silver, platinum, or graphite), while *outside* the battery, the electricity passes from this latter round through the wires, galvonometer, or other circuit open to its passage, back again to the zinc plate. (See Fig. 4, where the direction of the undulation, or "current," is shown by the

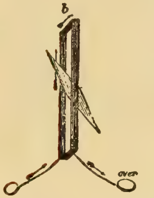
arrows; the plate marked Z being zinc, the one marked C being carbon, copper, or other conductor; W W being the wires forming the *poles* or *electrodes*.) If the positive pole (the one from which the "current" is flowing, the wire attached to the C plate) of such a battery be connected to the galvanometer by means of the binding-screw marked "over," the other pole being attached to the other binding-screw, the north pole of the needle having previously been adjusted so as to lie between the two binding-screws, it will be found that the north pole of the needle will deflect to the *left* of the line of the coil; the operator being supposed to be standing at the binding-screw end of the galvanometer. Since the wire of our coil returns *below* the needle, it is evident that a positive current (an outflow of undulation) passing *over* the north pole of a horizontally suspended needle, of a negative current (an influx of undulation) passing *under* such a north pole, causes it to deflect to the *left*.

FIG 5.

a



b

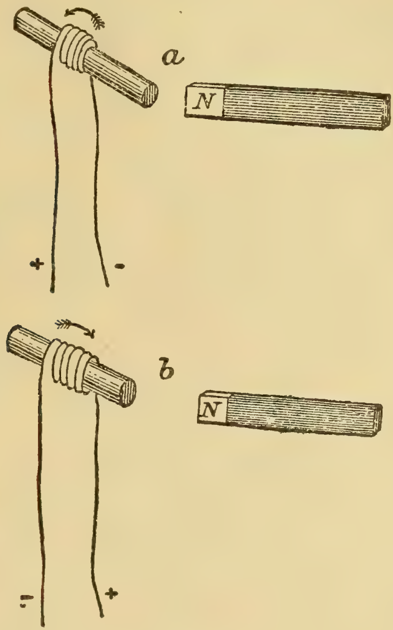


If we disconnect the battery and reverse the connections—that is, join the negative pole (the wire coming from the zinc) to the binding-screw marked "over," the other pole being connected to the other screw—the opposite effect results, viz., the north pole now deflects to the *right* of the coil. This will be understood by reference to Fig. 5, in which *a* represents the effect of the positive current flowing *from* the operator *over* the needle, the north pole in both illustrations being nearest to him; in *b* the positive current is supposed to be flowing *from* the operator, *below* the needle, in either case returning to the battery the opposite way.

§ 5. The effect will enable us at once to recognize, by means of our galvanometer, the *direction* in which a current is traveling; for, on connecting the two terminals of any source of electricity to the binding-screws of the galvanometer, while the north pole is in a line with the coils, between the two binding-screws, the operator facing the north pole of the needle, it is evident that if the north pole of the needle is deflected to the *left*, the terminal at-

tached to the binding-screw marked "over" is *positive;* but that if the north pole deflects to the *right*, then the said terminal is *negative*. It must be borne in mind that by the term *positive* in this connection is meant the point *from* which electricity is flowing, negative being the point *toward* which it is flowing, or *at* which it enters. This power of

FIG. 6.



recognizing the direction of a current will be found of great service to us in the construction of the dynamo.

§ 6. Returning now to our experiments with the magnet (see latter portion of § 3), and using in preference a straight soft iron rod, about 6 inches in length and ½ inch in diameter,

coiled with about 100 feet of No. 24 covered wire as our armature, and a good bar magnet to produce the electrical effects, we shall find, on coupling up the armature wires to the galvanometer, and approaching one end of the armature to or receding it from the north pole of the magnet, that the electrical flow set up is always in one direction in approaching or making contact, and in the opposite direction on receding or breaking contact. Fig. 6 will make this clear. The arrow at *a* shows the direction of the current produced on approaching or making contact with the north pole of a magnet; *b* illustrates the direction of current produced on receding from or breaking contact with the north pole of a magnet. If now we reverse the experiment by presenting the south pole of the magnet to the coiled armature, we shall find that the direction of flow is also reversed; that is to say, the *withdrawal* of a south pole produces the same effect as the *approach* of a north pole, and *vice versâ*, the *approach* of a south pole is equivalent in its effects to the *recession* of a north pole. It must be noted that the direction in which the wire is coiled round the soft iron rod (or armature), while it has no influence on the direction of the electrical current set up round the iron rod (which is always the *reverse* to the hands of a clock in the face *approaching* the north pole) determines the extremity of the said wire at which the current leaves or enters the coil. In the figure we have supposed the wire to be wound from *left* OVER toward *right;* had we wound our rod from *left* UNDER toward *right*, the opposite ends of the wire would have been respectively + and —. This must be borne in mind when we proceed to actual work.

§ 7. *Currents can produce Magnetism*,—If we take the coiled soft iron U, of which we made use § 3, and apply it to pieces of soft iron, nails, filings, etc., we shall find that it possesses little or no magnetic power of attraction; but if we couple the projecting ends of the coiled wires one to each terminal of a single-cell battery, we shall find that the U will become powerfully magnetic, retaining its magnetism as long as electricity flows around the coils, but losing nearly all the instant that the flow is caused to cease, either by breaking connection with the battery or by any other interruption. The rapidity and completeness with which the iron loses its magnetism depends almost entirely on its *softness* and *purity*. Anything which tends to put a strain on the molecules of the

iron, such as hammering, filing, twisting, sudden cooling, vibration, etc., render it liable to retain magnetism, or increase its *coercitive* force; whereas raising to a high temperature and very gradual cooling, which allows the molecules to range themselves with little or no strain, furnishes a soft iron, eminently incapable of retaining magnetism, or possessing little *coercitive* force.

§ 8. The direction in which the flow of electricity takes place around the iron bar decides which end of the bar acquires *north-seeking*, and which *south-seeking* polarity. Let us suppose as in Fig. 7, A, that one extremity of the bar be made to face us, and that the current be caused to flow in the direction of the motion of the hands of the clock; in this case, the farther extremity of the bar becomes a *north-seeking* pole, while the nearer extremity becomes *south-seeking*. The direction of the current, and consequently the polarity of the bar, may be reversed by joining up the *opposite* electrodes cf the battery (or other source of electricity) to the ends of the wire coiled round the bar, as shown at B; where, as the wire is joined to the electrodes in a manner just the reverse to that shown at A, so also the current enters at the opposite end of the wire, and produces contrary magnetic effects. The same result may also be attained by coiling the wire around the bar in the contrary direction, while leaving the connection with the electrodes unchanged, as represented at C (Fig. 7*a*). Perhaps the simplest means of remembering the relation which exists between the direction of the current and the position of the magnetic poles produced, is one known as "Ampère's Rule," in which the experimenter considers himself to be swimming head foremost, *with* the current, along the wire, *always facing* the iron core; *then* the NORTH-SEEKING POLE will always be at his LEFT HAND. (See Fig. 8).

Fig. 7.

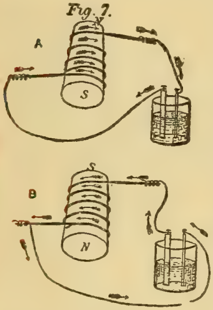


FIG 7a.

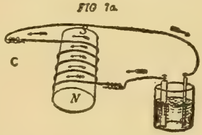
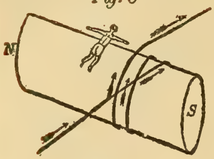


Fig. 8

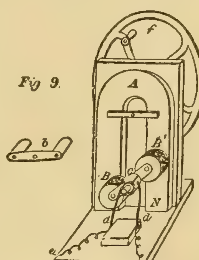


§ 9. It must be borne in mind, as being of the greatest importance in the construction of successful dynamos, that although *steel*, or hard iron, when subjected to this inducing action of the current, becomes *magnetic*, yet it does not acquire nearly such powerful magnetism as soft iron; and, in fact, the softness of the iron, and its capacity for becoming powerfully magnetic, run side by side. On the other hand, it must not be forgotton, as we learned at § 7, that the softer the iron the sooner it loses the magnetism imparted to it; while the harder brands of iron (and more especially steel) retain nearly all the magnetism which it is possible to confer upon them.

§ 10. The student who has carefully and intelligently performed the experiments described in the previous sections, will now find himself in a position to understand the principles which underlie the construction of the dynamo, even though he may have little or no previous knowledge of electricity. The first machine constructed after Faraday's discovery was that of H. Pixii, in 1832. In this machine a powerful horse-shoe magnet was caused to rotate rapidly before a soft iron U-piece, wound with insulated copper wire, the two extremities of which were prolonged by two brass springs pressing against a rotating split collar of brass, whose office was to rectify the direction of the currents produced by rotation of the magnet, before the iron core; currents which, as we have seen (§ 4), are in different directions, according to whether a given pole of a magnet is *approaching* to or *receding* from the core. This arrangement for causing alternating currents to flow in one direction, is known as the *commutator*, and it, or some modification of it, is most extensively used in all dynamos in which it is of importance that the current should flow in one direction only. The chief disadvantage in this machine was that of having to rotate a heavy magnet (built up of a number of thin steel plates), since the mere rotation tended to destroy, or at all events, to weaken its magnetism. In 1833 Mr. Sexton had the happy idea of fixing the heavier and causing the lighter portions of the apparatus to rotate: in other words, the magnet (or magnets) was now made a fixture, while the U-

shaped soft iron armature, with its surrounding coils of wire, was caused to rotate rapidly before it, on axis or spindle, either by gear-wheels or wheel and band. Mr. E. M. Clarke, in 1834, noticed that the *thickness* of the wire coiled round the armature had a considerable influence on the nature of the current produced by these machines. If the wire employed be very thin, say about the $\frac{1}{100}$ of an inch in diameter, and a large number of convolutions be coiled around the legs of the armature, the electricity produced is of high *tension*, capable of overcoming considerable resistances, and of giving severe shocks. If, on the contrary, a smaller quantity of a much thicker wire, say from the $\frac{1}{14}$ to the $\frac{1}{18}$ of an inch be made use of, the current produced is that known as a *quantity current*, or a "large" current, possessing but little power of overcoming resistances, not capable of giving shocks, but giving fine large sparks and able to decompose water, and other chemical bodies. Clarke usually furnished two armatures with his machines, one wound with about 1,500 yards of covered wire $\frac{1}{96}$ of an inch in diameter, which he designated the "intensity" armature; the other, wound with about 40 yards of wire $\frac{1}{18}$ of an inch thick, to which he gave the name of the "quantity" armature. One peculiarity of the machines turned out by Clarke was the fact of the rotating U-shaped armature being made to rotate near the flat *sides* of the magnet instead of *in front* of the poles. This, though it facilitates somewhat the mechanical arrangements, is open to some objections on the score of lesser efficiency, since the most active portion of the magnet is certainly *in front* of the poles. As Clarke's machine embodies nearly all the principles found in later dynamos, we shall give an illustration, together with detailed explanation of the commutator, etc., in our next paragraph.

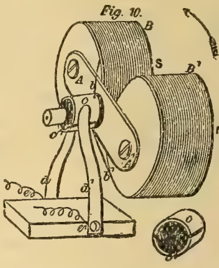
Fig 9.



§ 11. In Clarke's machine the horseshoe magnet, A, Fig. 9, is clamped to a rigid backboard, which is mortised to the baseboard. In front of this magnet, and in close proximity to its poles, is the armature B B′, which can be made to rotate on its axis at *c*, which passes right through the backboard, behind which

it is supported on bearings. The distant end of the axis is fitted with a pulley, around which plays a band or gut coming from the fly-wheel *f*. On turning the handle of *f*, the small pulley enters into rotation, carrying with it the armature. This armature (which represents the U-piece described at § 3, Fig. 3) is really constructed of three pieces of very soft iron, two short circular bars and a cross-piece, held together by screws, as shown at *b*. Around the two bars is carefully coiled the insulated* copper wire, in such a manner that, if the bars were straightened out, the winding would be always in one continuous direction, either from *left* over to *right*, or *vice versâ*, and the two extreme ends of the wire are brought out and joined metallically with the two metal half-cylinders which form the commutator *c*. This commutator is illustrated more fully at Fig. 10

Fig. 10.



c. Against the commutator press the two brass springs *d* and *d*′, to which are connected the wires *e* and *e*′, which form the real *electrodes* or *poles* of the machine. Fig. 10 shows how the wire is wound round the two soft iron cores B and B′, which are screwed to the soft iron cross-piece at A and A′, thus constituting virtually a coiled U-piece. The two ends of the wire which forms these bobbins come out at opposite sides of the bobbins, and are soldered or screwed to the half-cylinders (of brass) *c* and *c*′, as shown at *b* and *b*′. In order that the two cheeks of the commutator, *c* and *c*′ (which are shown separately to the right-hand of Fig. 10), should not allow the electricity to escape from one to the other, the spindle which carries the bobbins B B′ and the cross-piece A A′, is encased in a thick ring of ivory, baked boxwood or other insulator, which in the illustration is shaded darkly.

FUNCTION OF THE COMMUTATOR.—§ 12. If we follow one of the bobbins of the armature during its revolution before the poles of the magnet, we shall find that it changes its magnetic condition, and consequently its electrical state, *twice* during each revolution. Let us take, for instance, the bob-

* A body is said to be insulated when surrounded by substances which prevent the passage of electricity.

bin B′ in either figure in its rotation from the north pole of the magnet toward the south pole, as we learnt at § 6, *leaving* a north pole or *approaching* a south pole produces the same effect; and this effect will be that a current will flow round the bobbin from the right over toward the left. Hence, if the wire (which is coiled round the bobbin in the same direction) have its corresponding extremity joined to any circuit, this extremity will be found to be negative. In practice this extremity is actually connected with the cheek c' of the commutator. This cheek c' during the whole of the semi-revolution of the bobbin B′ from north to south, is being pressed against by the spring d', which, with its wire e', is consequently kept continuously in a negative state until the bobbin B′ has arrived quite opposite the south pole of the magnet. At this instant the spring d' touches neither of the brass half-cylinders, but presses against the ivory, boxwood, or other insulator, which separates the two half-cylinders of the commutator c and c'. Hence, no current flows; but directly B′ leaves the middle of the south pole and begins to complete the under half of the revolution, its cheek comes into contact with the spring on the opposite side, d. But now we find that the bobbin B′ is leaving a south pole to approach a north pole; therefore, according to § 6, the current is flowing in the opposite direction round the bobbin. Therefore the spring d collects from the cheek c' *positive* electricity. What has been said of bobbin B′ is, of course, equally true of bobbin B at similar points of its revolution; hence we see that, although each bobbin becomes alternately north and south as it approaches the south or north pole of the permanent magnet, and sends therefore a current alternately in contrary directions, yet, since (owing to the insulated half-cylinders) we are able to cause *one* spring to pick up the current from the bobbins whilst the free extremity of their encircling wire is sending a positive current only (the *other* spring picking up the current only whilst the free extremity of the coiled wire is negative), it follows that the springs d and d' are maintained in oppositely electrified conditions. It must be borne in mind that the wire is coiled continuously round both bobbins; hence, that as the bobbins are always exposed at the same time to opposite magnetic influences, so the conditions of the two extremities of the coiled wires are electrically opposite—viz., while one is *positive* the other is *negative*, and *vice versâ;* but that as the bobbin, whichever it be,

which travels from north over to south has the free extremity of its wire always *negative* and in connection with the spring d', while the bobbin (each in turn) which passes under from south to north has its extremity always *positive* and in connection with the spring d' it follows that, providing always the motion be that indicated by the arrow in Fig. 10, the spring d' will always be kept in a *negative* condition, while the spring d will simultaneously be *positive.*

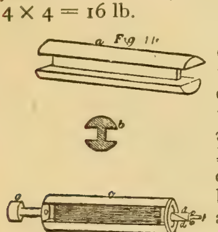
Since the comprehension of the function of the commutator is of the highest importance in the manufacture of the dynamo, we recommend the amateur to digest carefully the contents of this last section.

§ 13. The next great step in the development of the dynamo was the application of the current generated by the armature to the heightening of the magnetism of the magnets which set up that current in the armature. We have seen (§ 7) that a current sent round a mass of soft iron converts that iron into a magnet; and we find that the intensity of magnetization is, up to the point of saturation, proportionate to the quantity of electricity flowing round the iron. We also know that magnets produced by such means (that is, the passage of currents *around* soft iron cores) are much more powerful than permanent steel magnets of equal size and weight. Hence, apart from the question of less expense and greater constancy (for steel magnets gradually lose their power by the continuous motion of the armatures before their poles), there is actually a great gain in efficiency in employing *electro-magnets* instead of *permanent magnets* wherewith to induce the current, in Hjorth's machine (which was perfected so far back as October, 1854) two compound cast-iron magnets A A (Fig. 11), which may or may not be surrounded by a coil of wire, are bolted to the frame of the machine. These magnets are shaped like the letter C; and in the gap between the poles rotates a wheel, B B, on the circumference of which are fastened several armatures consisting of soft iron cores wound with insulated copper wire, the ends of which are brought out to a peculiarly constructed commutator, which rectifies the dissimilar currents produced. The wheel (and consequently the armatures) is caused to rotate by means of the rigger C and driving-axle. Around these movable armatures, and also bolted to the frame, are several soft iron cores wound with insulated copper wire, D D D D.

The currents produced in the first instance by the passage of the armatures before the poles of the magnets, A, after being rendered uni-direction by means of a commutator, are led on through wires to the coils which surround the soft iron cores, D D D D. These become, therefore, powerful electro-magnets, and induce in their turn more powerful currents in the armatures. The larger currents thus produced, again reacting in their passage on the electro-magnets, superinduce a higher state of magnetism in them, and this again exalts the electricity generated in the armatures, and so on until the limit of saturation is reached. The current, after traversing the coils, is led to terminals to which connection can be made for exterior work.

It is remarkable that, although this discovery was so important, and the description and designs were so clear in the specification, so little attention should have been attracted to it. Soren Hjorth was, indeed, much before his time, many of the machines now doing excellent work being simply trifling modifications of his "magneto-electric battery."

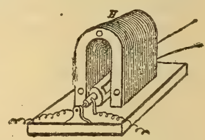
§ 14. The intensity of electric and magnetic effects does not increase in the simple proportion of the nearness of the bodies acted on, but in a much greater ratio, which, in the case of electrified bodies and permanent magnets, is *directly as the square of the nearness*, or (what amounts to the same thing) is *inversely as the square of the distance*. For instance, we find that a magnet which exerts a "pull" of 1 lb. on a given piece of iron at 6 inches, if placed at 3 inches, or *twice* the nearness, pulls with a force of $2 \times 2 = 4$ lb.; and if placed *four* times as near, namely $1\frac{1}{2}$ inches, pulls with a force of $4 \times 4 = 16$ lb.



It would appear that in the case of electro magnets the ratio between the distance and the effect increases even more rapidly, being, according to the best authorities, equal to *inversely the cube of the distance* nearly. Hence it struck Dr. Werner Siemens, of Berlin, that if the armature could be constructed of such a form as to allow of its remaining always very close to the poles of the magnet during its rotation, greatly exalted electrical effects would

result; and in 1856 he patented in this country the special form of armature represented at Fig. 11 *a*, so well known as the "Siemens" or "H-girder" armature. On reference to the armatures depicted at Figs. 9 and 10, it will be seen that during a considerable portion of their rotation they are at some distance from the legs of the magnets, and even when near them are not at the points of greatest action.

On the contrary, the Siemens armature is placed as nearly as possible at the most active portion of the magnet's poles—viz., their extremities, and at every portion of its rotation some portion of the armature is exposed to the action of the said poles. The Siemens armature, as shown at Fig. 11 *a*, consists of a cylinder of soft iron between three and four times as long as its diameter, around the sides and ends of which is cut a deep groove or channel, rather more than one-third the diameter of the cylinder. This is shown in section at *b*. The soft iron cylinder *c*, has brass heads and axes fitted to it as shown at *f* and *g*—the latter carrying a pulley or *rigger*, by which the armature can be rotated; while the former is encircled by the commutator *e e*, to which are attached the two ends of the insulated wire, which is wound in the channel. When in action this armature is placed between the poles of a compound horse-shoe magnet, and supported on trunnions or bearings at both ends; two springs pressing against the commutator carry off the electricity generated by the rotation of the armature, the motion being imparted by means of a band passing over the



pulley at the farther end of the armature. A general idea of this arrangement may be gathered by inspecting Fig. 11 H.

CURRENTS GIVEN BY THESE MACHINES NOT CONTINUOUS.

§ 15. Since the direction of the current changes at every semi-revolution of the armature in such machines as those of Clarke, Pixii, and Siemens, and at every passage of the compound armature before the poles of the inducing magnets in Soren Hjorth's machine, we are constrained to use a commutator whenever we desire to produce a current in one direction only. But the commutator, by the very fact of its being necessarily constructed of two or more portions of a metallic cylinder, separated by intervals of insulating ma-

terial, interrupts the passage of the electricity every time that the springs press against the insulating spaces. Hence the electricity furnished by these machines partakes more of the nature of rapidly succeeding waves, than of a steady continuous current, like that furnished by the battery. Still, when the armature is rotated at a high speed (and the Siemens requires to be driven at about 3,000 revolutions per minute, to give the best effects), these waves succeed each other with such rapidity as to simulate a steady current, no break in continuity being perceptible to ordinary tests.

Rapid Magnetization and Demagnetization produces Heat.

§ 16. It is found that the sudden change from north magnetism to south magnetism, which takes place in each half of the above described armatures, as they pass over from before a south pole to before a north pole of the inducing magnets, is accompanied by a very considerable rise in temperature; and that this rise increases with the rapidity of change of magnetism, which in its turn depends on the rapidity of rotation. So marked is this rise of temperature, that a dynamo fitted with a Siemens armature of the pattern figured at § 14, and started at an initial temperature of 10° C., rises in about twenty minutes to nearly 50° C., when driven at 3,000 revolutions per minute. This rise in temperature is detrimental to the efficiency of the machine:—1st. Because the wires of the armature, becoming heated, conduct less freely; hence loss of current. 2d. Because the armature itself is not capable of such intense magnetisation when hot as when cold (a red-hot mass of iron is hardly affected by the magnet); hence another loss of current. 3d. Because the insulating covering of the wire is impaired, if not actually ruined, if the temperature exceeds a very moderate limit.

For these reasons it is important to keep the temperature of the armature as low as possible. The first successful step in this direction was taken by Dr. Pacinotti, of Florence, in 1860, who constructed an armature of soft iron, in the shape of a ring around which were coiled, in successive sections, helices of insulated copper wire, the ends of which were joined up to a divided ring commutator The ring armature of soft iron, with its covering of wire, was supported on a central axle, and rotated before the poles of a magnet, either permanent or electro. At no part of the revolution is such

a ring taken as a whole farther from, or nearer to, the poles of the magnet; and although its magnetism is constantly changing, yet the change is not abrupt, but gradual and continuous; as will be explained in the following paragraph.

PACINOTTI'S RING ARMATURE.

§ 17. The description and illustration of this machine is to be found in the *Nuovo Cimento* for the year 1864, under the heading of "Una Descrizione d'una Piccola Macchina Elettro-Magnetica." The machine itself, as described, can be used either as a motor, or as a generator of electricity; and its adaptability to either purpose was specially dwelt upon by Dr. A. Pacinotti, in his communication; but it is only under the aspect of a generator that we shall stop to consider it here.

Two electro-magnets, S, N, Fig. 12 (which may, or may not, be united together below), are fastened to a baseboard, and so arranged that the upper extremity of one is a north pole, while the other is a south pole. These poles are furnished with semi-circular prolongations B B, B′ B′, between which is poised, on the axis C D, a soft iron ring A A. This ring is attached to the axis by means of radial arms. Coils of insulated wire are wrapped round the ring at short intervals about its periphery, the end of each coil being brought down the axis at D and attached to one of the small copper strips at E (of which there are as many as there are coils around the ring), the wire beginning the next coil being also metallically connected to this same strip. The wire terminating the next coil is fastened to the next strip, from whence starts a fresh coil, and so on, until all the strips, which form the compound commutator E are connected to the coils in such a manner that the end of one coil, by its attachment to its strip, forms the commencement of the next. Consequently, the wire forming the coils, although capable of communicating electrically with the springs F F at opposite points of the diameter of the commutator, is really continuous. The ring A A is

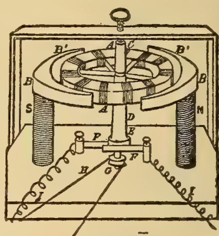


Fig 12.

caused to rotate by means of the rigger G and the driving belt H.

It will be evident on reflection that the half of ring opposite the pole marked N will acquire by induction *south magnetism*, while the half facing the pole S will for a similar reason become *north.* Hence the ring, whether in motion or at rest, will, provided the electro-magnets be active, become a circular magnet, with the south pole facing the north pole or the electro-magnet, and its north pole facing the south pole of the electro. When the ring is rotated, though if viewed as a whole, this magnetic condition remains unaltered, yet, of course, any given portion of the ring will gradualiy change as it passes over from one " horn " or prolongation of the magnets to the other). Still, the change which takes place is not abrupt, but gradual, and partakes more of the nature of a *wave* than of *shock.* So also, since the springs of the commutator press on several strips at the same time, at no time is contact ever entirely broken between the commutator and the springs; therefore the current which is produced as a continuous wave, *always in one direction*, is collected in a similar continuous manner by the springs F F, and may be employed where required by coupling up the wires I I.

This machine, discovered more than twenty years ago, embodies all the essential characteristics of the best modern machines, and the much vaunted machines of Gramme, Brush, Siemens-Alteneck, Maxim, Edison, etc., are, at best, but trifling modifications of the Pacinotti ring machine—modifications which have not always been improvements. Having now brought our brief sketch of the essentials of a dynamo to a close, we shall proceed in our next section to constructive details.

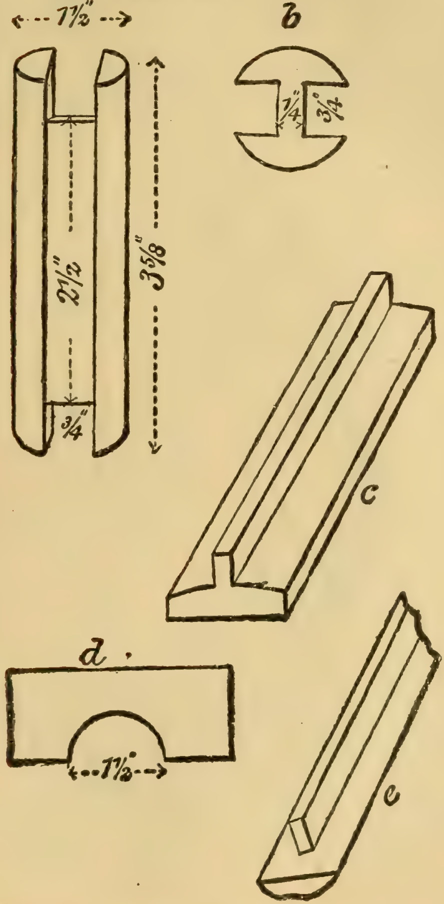
The Patterns.

§ 18. In the dynamo we are about to construct, three separate pieces for patterns are absolutely necessary—viz.; one for the armature, one for the legs of the field magnets, and one for the standard which supports the fly-wheel. There is no necessity for the amateur to put himself to the trouble of cutting out a pattern for the flywheel, since such wheels with handles already fixed can be had for a dollar or so. In constructing the wooden patterns, from which the iron castings are afterward to be procured, the amateur should remember to choose dry, well seasoned wood, free from knots. Red pine, for such small work as is required, will be found as

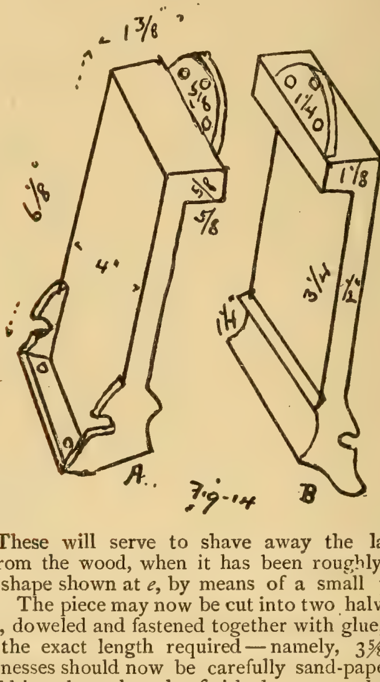
good as any. Any joints that are absolutely necessary (and joints should be avoided as much as possible) should be attached together with dowels and glue. It must be borne in mind that the molder places the patterns in *green* (moist) sand, and that this moisture causes ordinary glued joints to come undone or expand. Any roughnesses left on the pattern also swell up, catch the sand, and thus destroy the sharpness and beauty of the mold, and therefore of the resulting casting. It is therefore advisable, after having got the wooden pattern to the highest possible degree of smoothness and trueness by means of emery-paper, etc., to give it a coating of melted paraffine wax, and polish the surfaces carefully with a roll of flannel. This renders the surfaces not only extremely smooth but impervious to moisture, so that the pattern does not warp or swell when placed in the sand. In order that the pattern should come clean out of the sand and not break away any portion of the mold, care must be taken that the edges be slightly rounded, so as to give what is technically called *clearance*. The possessor of a *lathe* can turn up many portions of the fittings with much greater accuracy and rapidity than one provided with only ordinary tools; but in the ensuing directions the amateur is supposed to possess tools of the simplest kind only.

§ 19. The pattern for the *armature* first demands our attention. When completed, it presents the appearance shown at Fig. 13, *a* being the elevation and *b* the section, on a scale of about half the real size, and consists of a wooden cylinder $1\frac{1}{2}$ inches in diameter by $3\frac{5}{8}$ inches in length, with a deep channel round the ends and sides. To construct this pattern, procure a piece of pine 8 inches long by $1\frac{1}{2}$ inches wide and $\frac{3}{4}$ of an inch thick. Lay this on a table on its widest side, and draw a line along its whole length, that shall divide it into two halves of $\frac{3}{4}$ of an inch each. Now, draw a line on each side of this central line, rather better than $\frac{1}{8}$ of an inch from it. Holding a metal rule against one of these side lines, with a sharp penknife, cut into the wood along the line to a depth of about $\frac{3}{8}$ of an inch—rather less than more. Now, perform the same operation on the other side line to the same depth. With a sharp $\frac{1}{2}$ inch chisel, shave away the wood on the outside of the cut lines to the depth of $\frac{3}{8}$ of an inch on the outsides, but *rising up very slightly toward the center*, as shown at Fig. 13, *c*. This precaution will ensure the pattern lifting out clear from the mold.

a Fig. 13.



Now, take a piece of stout cardboard, and with a pair of compasses strike out a circle $1\frac{1}{2}$ inches in diameter. Cut the circle out of the cardboard so as to leave a clean circular aperture of the diameter specified. This is to serve as the *templet*, or gauge, of the size and general truth of our armature. Strike out, also, in a similar manner a circle in a piece of stoutish zinc, or tinned iron, also $1\frac{1}{2}$ inches in diameter, and cut this into halves (one of which is shown



at *d*). These will serve to shave away the last irregularities from the wood, when it has been roughly trimmed up to the shape shown at *e*, by means of a small plane, or penknife. The piece may now be cut into two halves across its length, doweled and fastened together with glue, and cut down to the exact length required — namely, $3\frac{5}{8}$ inches. All roughnesses should now be carefully sand-papered, and care should be taken that the finished pattern should pass exactly through the cardboard pattern, being appreciably

neither thicker nor thinner at any part. When this has been effectea satisfactorily, a small quantity of paraffine wax (a piece of paraffine candle will do) should be melted in an iron spoon, and well rubbed into the pattern at all points with a roll of flannel until it is thoroughly impregnated with the wax; rubbing the pattern until it acquires a polish completes the operation, and renders it ready for the founder. The thin central portion, which joins the semi-circular portions, should be about 2½ inches in length, having rather more than ½ an inch cut away at each end, so that the channel is continuous round the armature, being ¾ of an inch wide and about ½ an inch deep all round.

§ 20. The pattern for the *legs* of the electro-magnet (*field magnets*, *exciting magnets*) will next require our care. Since the two legs are exact counterparts, the one of the other, so we need only make one pattern, from which, however, *two* castings must be obtained. Fig. 14 illustrates the form and dimensions of this pattern on a scale of about one-quarter the real size. The dimensions are marked in inches. A represents the outside view, *i.e.*, as seen from the side which is farthest from the armature; B gives the view from the inside (close to which the armature rotates).

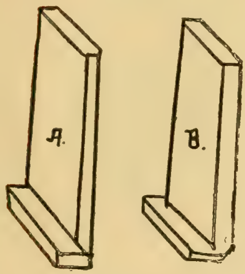
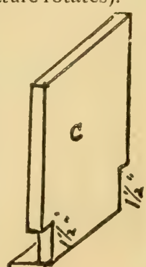


Fig. 15.

To make this pattern, procure a piece of pine 6 inches in length, 4 inches in width, and ½ an inch thick, planed smooth, and free from knots and roughness. Glue the dowel along the bottom edge a strip 1⅛ inch wide, 4 inches long, and ¼ of an inch thick, as shown at Fig. 15, *a*. Now, with a sharp plane, remove half the inner edge, as shown at Fig. 15, *b*, so that it makes an angle with the edge of the 6-inch piece. With a fine saw cut a recess on each side of the jointed piece 1½ inches long by 4 inches deep,



as shown at *c*, and glue and dowel in each recess the two flanges, made of ¼-inch stuff, of the shape and dimensions given at *d*. To insure the slot *e* being exactly at the same point in each flange, the two flanges, after being roughly shaped with a fretsaw, or other wise, should be clamped together, and the finishing touches given with a rat-tail file, for the slot *e*, and with sandpaper along the rounded edges. Care must be taken that these flanges should be a trifle thinner near the edge marked 1¾ than on the opposite edge, to insure the pattern coming out clean from the mold. For this reason the slot *e* must not be narrower at the outside than at the inside, but rather the contrary. The slot *e* must

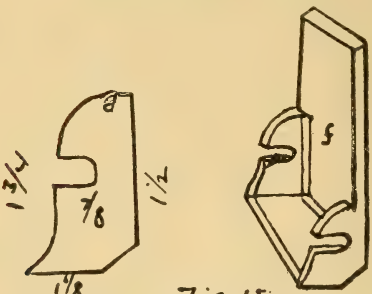
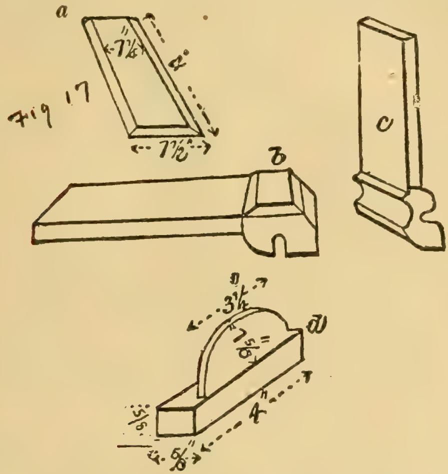


Fig. 15.

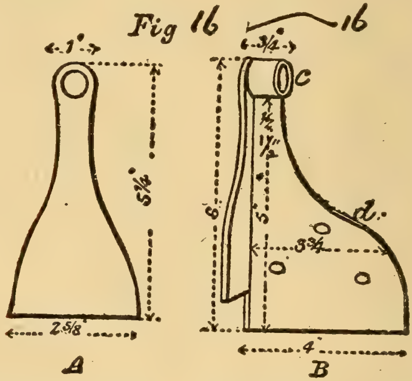
be ¼ of an inch wide, and must reach in depth to the 6-inch piece, to which the flanges are attached. At this point our pattern will present somewhat the appearance shown at *f*. A piece of wood 4 inches long by 1½ inches wide, and ¼ of an inch thick, perfectly smooth, square, and free from knots, must now be chosen, and the two sides planed away, on the upper side to such an extent as to make an angle of 60° with the base. (See Fig. 17, *a*.) With some good, thin, hot glue this piece is to be glued along the bottom edge of the 6-inch piece, on the side opposite the flanges, and in such a manner that the slope of the base is continued by the slope of the piece, as shown at Fig. 17, *b*. When the glue is quite dry, by means of an inch gouge, cautiously hollow out along the entire length of this piece, in a simicircular form, nearly to

the depth of the original 6-inch piece, so as to fit accurately the pattern of the armature which has already been made. (§ 19.) When this is as true and smooth as it can be made with the gouge, fold a piece of fine glasspaper over the pattern of the armature, rough side outward, lay the armature in the channel, and work it backward and forward until perfect smoothness and a perfect fit are insured. The pattern should now present the appearance given at Fig. 17, *c*. When this end has been attained, four small dowels should



be inserted into the thicker portions of this semicircular piece, to hold it firmly down to the 6-inch piece. We now need only make the top flange, by which the bracket or standard that bears the wheel is clamped to the legs of the dynamo. This is made most easily in two pieces, one being squared up to 4 inches long, ⅝ of an inch thick by ⅝ of an inch wide. The other piece is to be ⅜ of an inch thick, and must be cut into a perfect semicircle, with a radius of 1½ inches. By means of glue and a couple of dowels, this is neatly attached to one side of the other square piece, as

illustrated at Fig. 17 *d*, and then the whole is carefully and squarely glued and doweled, in like manner, to the top of the 6-inch piece, so that it now presents the appearance shown at A and B, Fig. 14. The holes shown in the bottom and top flanges may be bored, and core prints inserted, *if the founder will take the trouble to put them in his mold;* but, as a rule, founders do not care to cast small castings with holes in them, as they seldom come true, so that it will be, perhaps, as well to have them bored afterward, which can be done at a small cost. This pattern must now be carefully smoothed,



the sharp edges rounded, to insure parting from the mold and finally parafined and polished, as recommended for the armature (§ 19), when it will be ready for the molder.

§ 21. The next pattern to be made is that of the *standard*, which supports the driving-wheel. This should be made out of ¼-inch stuff, a piece of which 5¼ inches long by 2⅝ inches wide must be cut to the shape shown at A, Fig. 16* (one-quarter the real size). In order not to split the top while boring the hole, it is as well to bore the hole (which should be ½ an inch in diameter) before shaping the piece. For the same reason, the piece marked C, which should be ½ an inch thick and 1 inch in diameter when finished, should be glued to the center of the top end of the piece A, and the whole bored (by means of a brace and sharp ½-inch

center-bit) before trimming up to shape. From the same ¼-inch stuff, another piece, figured at B, is cut out, being ½ an inch wide at the top, sloping gradually, and becoming wider to about half its length (*d*) when it should sharply curve to a width of 4 inches. The length of this piece should be 5 inches, and it is to be glued and doweled to the center of the piece A, close against the boss C, as shown at B. A small piece *e* must now be glued and doweled to the edge of the curved flange, so as to make it flush with the front A. When this has been smoothed and polished with paraffine, the patterns are ready for the foundry. The three holes shown at *d* may be bored in the castings.

The Castings.

§ 22. The patterns may now be sent to the foundry, with the following instructions: First, the armature should be carefully annealed, so as to constitute a *malleable iron casting;* second, two legs should be cast from the pattern shown at Fig. 14, and these also must be carefully annealed, and be made as soft as possible; third, the standard (Fig. 17, B) will be better if left pretty hard, as in this way it will retain sufficient magnetism to start the machine without adventitious aid. Particular stress must be laid on the importance of the iron in the armature and legs being *very soft,* since much of the efficiency of the dynamo will depend on this point. (See § 9.) When the castings return from the foundry, their degree of hardness may be tested by trying with a rather coarse file. If the file bites easily, the iron is fairly soft; if it slips over without filing, it is altogether too hard. (This does not apply to the standard, which may be left quite hard without any detriment to the machine). The armature must now be cleaned and trued up. If the student be the happy possessor of a lathe, this will not prove a difficult job; if otherwise, he may, by careful filing, remove any irregularities, and square up the ends. These must be made quite true; otherwise it will be impossible to center the armature so as to rotate it between the poles of the magnet. The thin central portion shown at *a*, Fig. 13, and there marked 2½, must have its edges rounded, so as not to cut the wire, which will have to be wound round it. No trouble should be spared to get the armature as truly cylindrical as possible; as care expended at this portion of the process will render the remainder of the work very much easier, and more satisfactory. The

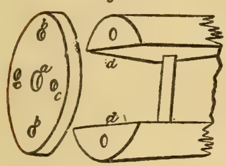
armature having been thus rendered true, the legs will demand our attention. Having gone over the surface with a bastard file to remove any irregularities, the curved channels, shown at A and B, Fig. 14, must be carefully cleaned out. Perhaps the quickest way to do this, and to clean the armature at the same time, is to lay the two pieces, channels uppermost, on a table, putting a little fine sand and water in the channels, and then to work the armature up and down the channels, first in one and then in the other, alternating also the sides of the armature, until the channels, as well as the external surfaces of the armature, are rendered quite smooth and bright. The sharp corners of the legs of the magnets around which the wire has to be coiled must also be rounded, and the top semicircular flanges, between which the standard has to be clamped, must be filed quite flat on their inner surfaces, and made perfectly parallel with the portions marked 3¼ B, Fig. 14. The standard must also be cleaned in like manner, particular care being taken that the two sides of the piece marked B, Fig. 16, be perfectly parallel. The edges of the front piece *e* must be made perfectly square and true, so as to fit exactly on to the top of the two legs of the magnets, Fig. 14.

§ 23. Before winding the armature and field-magnets with the wire in which the electricity is at once generated and conducted, it is necessary to fit together accurately the different portions, and *mark them*, so as to be able to put them together again in precisely the same position after winding; since no filing or fitting can be attempted on the castings after the wire has been wound without almost certain destruction of the insulation, and certain ruin to the neat appearance of the evenly-laid wire.

The part that calls for the greatest care and attention is the armature, which, as it must rotate in very close proximity to the poles of the field-magnets at a rate varying from 1,000 to 3,000 revolutions per minute, requires to be centered most accurately on its bearings or trunnions. This to the possessor of a lathe presents but little difficulty; for the benefit of those who depend on ordinary tools only, the following method, by which the armature can be mounted on its bearings in a fairly accurate manner, is described. With a pair of calipers, the diameters of the two opposite extremities of the armature are taken. (If the armature casting were finished up quite exactly, these two measurements would be exactly alike, viz., a trifle under 1½ inches each. But unless turned on the lathe, it is

very rare to get such precision.) Two circles, of exactly the same diameters as the two extremities of the armature, are now to be struck out of a piece of hard sheet brass, ⅛ of an inch thick, care being taken to mark the center and the circumference in an exact and bold manner with the compasses. These circles will have to be cut out of the brass with a saw or file, so as to get two discs, fiting each one to its respective armature extremity; but before cutting out the circles thus marked, three holes should be drilled in each, viz., one in the exact center $-\frac{3}{6}-$ of an inch in diameter, which is to take the driving shaft or trunnion, and one on each side of this center, ⅛ of an inch in diameter, to admit the screws which serve to attach these *heads* or discs to the iron portion of the armature. Besides these three holes, which are common to both "heads," another pair, also ⅛ of an inch in diameter, must be drilled in one of the heads, to allow the ends of the wire which is to be coiled around the armature to emerge from them, and pass through to the commutator All these holes are shown *full size*, and in their correct position at Fig. 18, where *a* is the central aperture, to take the shaft; *b b* the two holes to admit the screws, whereby the heads are attached to the armature; and *c c* holes drilled in one head only, to admit of the passage of wires to the commutator. These holes being bored, and the discs accurately cut out, two pieces

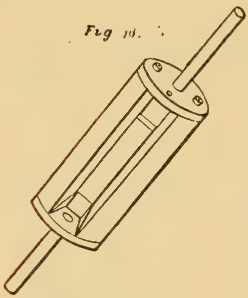
Fig. 18.



of hard-drawn iron wire (not galvanized) ¼ of an inch diameter and 2 inches long, are carefully straightened, and by means of a screw-plate, a thread is put on one end of each. With the corresponding tap, a female screw is cut in the central hole of each brass disc. The two iron rods are then screwed in, particular care being taken that they enter perpendicularly and centrally. They must be screwed in until they just protrude through to the other side; then the long end being allowed to slip between the jaws of a vise, while the disc rests flat upon the surface of the jaws, a few steady blows with a flat-pened hammer will spread the head of the screw end of the iron rod, so as to rivet it firmly to the disc, and thus prevent it working out. To render assurance doubly sure, a drop or two of soft solder may be run round the flat

side of the end of the rod and disc. Now we come to a part of the work that very few amateurs can do at home—viz., drilling the holes in the faces of the armature. Any blacksmith will, however, do this for a few cents. Four holes are required, two at each end of the armature (one end is shown real size at *d d*), and these holes must be tapped with a female screw, so as to take the screws which serve to unite the whole together. It will be well to let the blacksmith drill and tap these holes to any sized screw that he has nearest approaching ⅛ of an inch in diameter. Now will be also the time to get the blacksmith to drill the three holes, right through the top end of the legs and standard, which serve to allow these portions to be clamped together by means of bolts and nuts. These holes should be about ¼ of an inch in diameter. Further details as to position and size will be given a little farther on. If our work has been properly performed, the heads may now be screwed down to the armature with flat-headed screws, which should project about $\frac{1}{16}$ of an inch above the level of the disc. Fig. 19 gives a representation of the finished armature about half the real size.

Fig 19.



§ 24. Our next proceeding is to clamp together the standard, or bracket, which serves to support the wheel to the two legs of the field-magnets. At the concluding portion of § 23, we adverted to the advisibility of getting the holes bored right through the top end of the legs and standard, at the same time that the holes were being drilled in the armature. The position of these holes is indicated at Fig. 20; they should be about ¼ of an inch in diameter, and the two lower ones should be at least ⅝ of an inch from the bend of the flange, so as to allow the nuts to be easily turned and tightened up. These two bottom holes should be about two inches apart, while the upper one should stand equidistant from the others, but at about ½

Fig 20

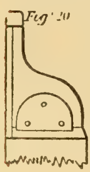
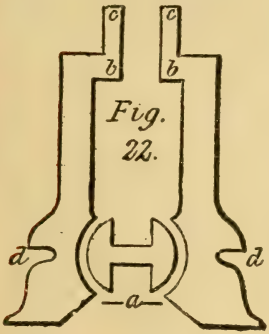


Fig 21

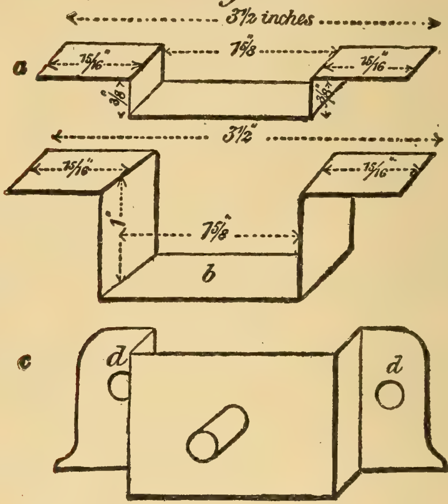
an inch from the top of the flange. The amateur will find at any hardware store, very neat skate-screws with nuts to fit, of the form illustrated at Fig. 21. These screws have usually rounded heads, without the slot for the screw-driver to enter; but these can be easily cut with a metal saw. Of course, any small bolts and nuts having a section of about ¼ of an inch will do, but the ones mentioned are very neat in appearance. The holes being drilled and the bolts and nuts chosen, the bracket and limbs of the field-magnet may be temporarily clamped together, in order to see what opening is left between the legs for the armature to turn in, at *a*, Fig. 22. In all probability some filing of the faces of the flanges and of the bracket will be necessary to insure a proper fit. A well-fitted armature, if placed in the center of the channels at *a*, should leave a space of a trifle more than $\frac{1}{20}$ of an inch to turn in; that is to say, there should be rather more than $\frac{1}{40}$ of an inch clear space all round between the armature and the field-magnets. Perhaps the quickest way to insure this distance being obtained is to roll tightly a single fold of stout brown paper round the armature and seal down the edge to prevent it slipping; then having inserted the armature in the channels, to file away at the inner faces of the flanges, either toward the lower portions at *b b*, if the channels are too wide apart, or at the upper extremities at *c c*, if too close, until the whole fits accurately together. It is needless to remark that when the armature thus wrapped in paper is placed between the field-magnets, to obtain a correct fit, *the solid portions of the armature should lie against the legs*, and *not* the portion of the armature which is hollowed out for the reception of the wire. (See Fig. 22.)



§ 25. The magnets and brackets being thus properly clamped together, the hole in the top of the bracket (which ought to have been left in the casting, but if not may be

bored now) should be cleaned out to ½ an inch in diameter. When this is done, two pieces of hard rolled brass sheet ⅛ of an inch thick, 6 inches long by 1 inch wide, must be cut out and squared up. One of these, which we shall for the future call the "back bearing," and which must be made to fit that end of the dynamo at which the driving wheel is to be placed, and which we shall henceforward call the "back" of the dynamo, is to be bent four times at right angles, as shown at Fig. 23, *a*, where the dimensions are given. In

Fig. 23.



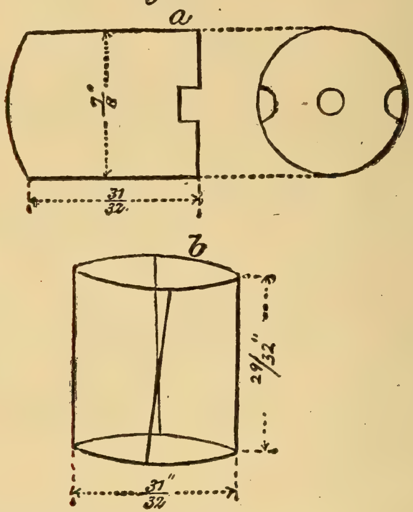
order not to crack the brass while bending to shape, it will be well, after having given the general form by bending gently and gradually over the jaws of a vice, to heat the bends over the flame of a spirit-lamp until nearly red hot, and then to hammer up more exactly to shape, repeating the heating after each hammering until the desired sharpness of outline has been obtained.

When this object has been attained, another almost similar bearing is formed out of the remaining piece of sheet brass, the principal difference being that, as this is to be the front bearing, between which the commutator will have to turn, a much greater depth must be given to the central bent portion, as may be seen at Fig. 23, *b*, the dimensions being given in inches as before. When the brass has been bent to these forms, the bearings thus produced should be laid each against its own respective end of the dynamo, in such a position that the center of the bend comes in the center of the channel, the two flat extensions lying close to, and flat against, the slotted lugs shown at Fig. 22, *d d*. The bearings should now be cut in a sloping fashion to follow the outline of the lugs, as shown at Fig. 23, *c;* but the outline of the slotted portion should not be followed, as a ¼-inch hole must be drilled in the brass at this point to take a 5-inch bolt and nut. The exact position of these holes may be obtained by holding each bearing in succession against its own proper extremity, and scratching with a steel point on to the brass the position in which the slots in the lugs fall; then, with a Morse twist drill, a ¼-inch hole can be drilled at each extremity *nearest* to the *center* of the bearing, as shown at Fig. 23, *d*.

Having got so far, let us clamp the back bearing in its place by means of two bolts about 5 inches long, passing through the holes in the bearings and through the slots in the lugs, held in their places by two nuts screwed down on to the front lugs of the dynamo. Taking the armature in one hand, we roll, as before, *one fold* of paper round it, and put a dot of Brunswick black on the extremity of the trunnion rod at the back end of the armature (the end where the holes are bored for the wire to come out is the front, the other is the back), and then insert it into the channel between the legs of the field-magnets, until the trunnion rod on shaft touches the brass forming the back bearing. In so doing it will leave a mark of Brunswick black, which will be the point at which a ¼-inch hole must be bored. This must be done most carefully, so as to preserve centricity; and when done must be rimed out and bushed with a piece of brass tubing of about $\frac{5}{16}$ external diameter, the internal diameter of which must exactly correspond with the external diameter of the driving-shaft or trunnion of the armature; in fact, this latter must fit exactly into the tube, without any

shake. This piece of tubing should be about 1¼ inches in length, and should be soldered into the central hole in the back bearing, and should extend inward to such a degree that when the back bearing is clamped in its place, with the armature in its position, with the back trunnion in the tube, and the back head flush with the back of the magnets, it should just rest against the back head of the armature.

Fig. 24



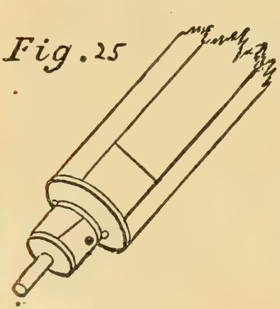
In a precisely similar manner the center of the front bearing is found; that is to say, the back bearing being removed, the front bearing is clamped to the front of the dynamo, the armature, rolled in one fold of paper, is inserted from the back end of the dynamo, front end forward, and care taken to moisten the front end of the driving-shaft with Brunswick black or other color, so as to get a mark where it touches. The hole being drilled and rimed out, as in the previous case, is to be likewise bushed with the same kind of

brass tubing; but in the front bearing, the tube should be only flush with the inside of the bearing, and *should not* extend in toward the armature.

§ 26. The *Commutator* next claims our care. This essential piece of apparatus serves, as the student may remember (§ 12), to rectify, or send in one direction, the vibrations or currents which are produced in opposite directions, as each pole of the armature passes alternately before the north and south pole of the field-magnets. In screwing the brass heads down to the armature, the student was advised (§ 23, Fig. 19) to employ flat-headed screws, projecting about $\frac{3}{6}$ of an inch above the level of the discs. The use of the projecting heads is to prevent the commutator slipping round the axis or trunnion of the armature when the latter revolves. The body of the commutator may be turned up out of a piece of sound boxwood, which previous to turning up should have been allowed to soak for a couple of hours in melted paraffine. It should, when finished, present the appearance shown at Fig. 24, *a*. While on the lathe, a hole, perfectly central, should be drifted right through it, into which the front shaft or trunnion of the armature fits tightly. The length of this should be $\frac{3}{32}$ of an inch, so that it just clears the front bearing when in its place. The diameter should be about $\frac{7}{8}$ of an inch, so that the two flat-headed screws of the front armature head should be covered by the cylinder on opposite sides of its circumference to the extent of about $\frac{1}{8}$ of an inch. Two semicircular nicks must be cut out of the bottom of the cylinder to allow these screw heads to enter, so that the cylinder when driven home rests quite against the disc or head. The front of this cylinder (the part farthest from the disc) must be rounded slightly, so as not to present too great a surface for friction against the front bearing. A piece of brass tube, $\frac{1}{8}$ of an inch shorter than the cylinder, and of such internal diameter as to fit tightly on it, is now cleaned up and cut into two exactly equal halves longitudinally. The cuts must not be quite parallel to the axis of the cylinder, but must make a small angle with it, in order that the "brush" or spring which takes the current off the commutator should at no time abruptly leave one half tube before it rests on the other; otherwise the commutator sparks badly while at work, and the sparks injure both commutator and brushes, besides entailing loss of current. The amount of angular deviation from the line of axis should not, in this machine, exceed two

or three degrees of arc, and care must be taken they are equi-distant, and both inclined in the same direction. To insure this, stand the tube (already cut to length and cleaned) on one end. Take the exact diameter with a pair of compasses, and strike out on a piece of card a circle of exactly similar diameter. Rule two fine lines across this circle, both cutting the center, but exactly $\frac{1}{8}$ of an inch apart at the circumference, like a letter X. Lay this card on the top of a tube, and with a steel point or file make a mark on the rim of the tube at each of the points where the lines touch the circumference of the circle. Now lay the tube on its side, and draw four lines straight along the length of the tube, starting from the points just marked. Each opposite pair of lines will be exactly $\frac{1}{8}$ of an inch apart, and quite parallel. Having done this, bring one pair of lines uppermost, and draw a diagonal line from the top of the right hand to the bottom of the left-hand line. Now turn the tube half a revolution, so as to bring the lower pair of lines uppermost, and draw a similar diagonal line, in the same direction—viz., from the top of the right hand line to the bottom of the left-hand line. Now, with a fine fretsaw cut the tube into two halves in the direction of the two diagonal lines just described. The tube, with the diagonal lines marked ready for cutting, is shown, as if transparent, at Fig. 24, *b*. It will be noticed that though, when seen *through*, these lines cross each other, yet when either portion of the marked tube is uppermost the line of division is from right downward to left. The split tube is now to be fastened to the boxwood cylinder in such a position that the middles of the lines of division shall be exactly in a line with the middle of the channel of the armature. (See Fig. 25.) These two half-tubes may be attached to the boxwood cylinder or core by means of two short flat-headed screws, care being taken that these screws do not reach to make contact with the trunnion or touch the "head" of the armature. The split ring,

Fig. 25



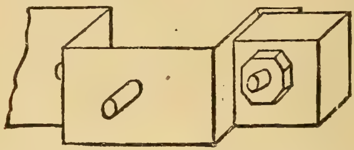
when fastened in its place, should reach to within about $\frac{1}{8}$ of an inch of each end of the boxwood core; and if screws are used to fasten it down these should be placed at the end nearer the armature. But another very neat and effective way of attaching the split tube or ring to the core is by means of two narrow ivory or bone rings, forced over the split tube, one at each end. Care must be taken, in either case, that the divisions in the split tube are maintained; for, of course, if the two halves of the tube were allowed to touch at any point the current would flow round at that point or "short circuit," and no current would be perceptible on the outside. To insure the distance being maintained, it is well to place a shaving of paraffined wood of the same thickness as the saw-cuts between the two halves of the split tube on both sides.

§ 27. Those who have not a lathe can make a very fair substitute for the boxwood cylinder by rolling and gluing a stout piece of brown paper, just as if making a rocket-case, around a piece of the same iron rod that served for the trunnions of the armature, until a cylinder $\frac{7}{8}$ of an inch thick and $\frac{31}{32}$ of an inch long has been produced. This should be rolled very hard while on the iron rod, so as to insure its being truly cylindrical; the rod on which it was rolled should then be pulled out, and the tube allowed to dry thoroughly. When dry it should be soaked for half an hour in melted paraffine, then reared on end to drain and cool. It will be found to work extremely well. Of course the split ring can be attached to this, either by screws or by two rings, as in the former case.

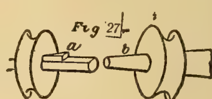
§ 28. Two rectangular pieces of boxwood (previously boiled in paraffine) must now be cut, planed and drilled. These are the "brush blocks," which serve to support the metallic springs or "brushes" which press against the commutator. Some operators prefer to mount their blocks on the stand, separate from the dynamo castings; here the plan followed is to cause the bolts which clamp the bearings to the field-magnets to carry the brush blocks. To this end the two pieces of boxwood should be cut so as to fit exactly the space left between the shoulders of the front bearings *on the outside*, and bored so as to allow the bolts to come right through to take the nuts; that is to say, the blocks will be almost cubical in shape, being 1 inch long, $\frac{15}{16}$ of an inch wide, by $\frac{3}{4}$ of an inch thick. Fig. 26 shows one of these blocks in its place, clamped to the bearing by the nut and bolt.

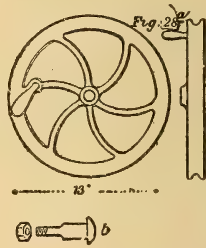
§ 29. In order to communicate the motion from the fly-wheel to the armature, a small pulley-wheel, either of iron or brass, is fitted to the back trunnion, just outside the bearing. Such a pulley-wheel may be bought at any hard-

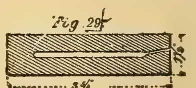
Fig.26



ware store, and should be about 1¼ inches in diameter, and rather over ¼ of an inch thick, with the central hole somewhat smaller than the diameter of the rod which serves for the armature trunnion. This may be attached to the trunnion in either of the two following ways: 1st. By "keying," which consists in filing the trunnion along its length in one direction only, so as to produce a flattened side; then, having with a rat-tail file cleaned out the central hole of the pulley to such an extent that the said trunnion will only just enter, to deepen one side (corresponding to the flattened side of the trunnion) so as to admit of a small steel wedge or "key" being inserted. (See Fig. 27, *a*.) 2nd. By filing the trunnion-rod to a slightly conical shape, and producing a similar "coning" in the interior of the pulley hole, which may then be driven on. (See Fig. 27, *b*, where the "coning" of the trunnion is exaggerated, to render this mode of attachment more plainly visible.) Which-







ever mode of attachment is adopted, one precaution must be taken — viz., that the distance between the back of the field-magnets and the pulley should not be *less* than 1¼ inches; otherwise, when the limbs of magnets are wound with wire, the fly-wheel will run too close to them to be altogether safe.

§ 30. The fly-wheel which gives motion to the armature should be a pretty heavy wheel, about 13 inches in diameter, with a groove in the rim to take the band which drives the pulley, furnished with a wooden handle for convenience of rotating. Such wheels may be obtained ready made in cast-iron, from most hardware or agricultural implement dealers, as they are sent out with "rotary blowers," "portable forges," etc. Fig. 28 *a* gives an idea of the kind of wheel necessary, on a scale of 1½ inches to the foot. The central hole is turned, and only requires fittting with an iron pin, on which it turns. Since the aperture in these wheels is about ¾ of an inch in diameter, the pin must be filed down to ½ an inch diameter, where it has to fit the hole in the flange at the top of the dynamo.

The farthest end should have a rounded head, to prevent the wheel from working off, while the portion which passes into the eye at the top of the flange must have a thread put on it, so as to take a nut. (See Fig. 28, *b*.)

§ 31. All the portions of the dynamo being now fitted, they should be marked so as to insure putting together again in right order after winding. When this has been done; the limbs of the field-magnets, at all parts except the channel for the armature, and the inner face of the semicircular top which rests against the wheel bracket, should receive a coat of good Brunswick-black, allowing them to dry between each application, in a warm oven. The bracket should likewise receive a coat or two of the same varnish, except where semicircular tops clinch it. This portion *must* be left metallic, so as to insure magnetic contact; otherwise much magnetic power is lost. Two strips of silk (color immaterial) 10 inches long by 3¼ inches wide, should now be quickly brushed over with Brunswick-black, and wrapped, while still sticky, one round the one limb, and the other round the other limb of the field-magnets, in the space between the armature channel and the bend at the top. (See Fig. 14, where the portions indicated are marked respectively 4″ and 3¼″.) The object of this silk

wrapping is to insulate the wire thoroughly from the iron, and to prevent any accidental abrasion of the covering wire, which may take place during *careless* winding from short circuiting to the iron below. When the silk has been laid smoothly and tightly on, the limbs may be returned to the oven, and allowed to dry at a gentle heat. In precisely the same manner the interior faces and their central portion of the armature (technically known as the "web") must be varnished with Brunswick-black, and wrapped with one layer of similarly prepared silk. Three pieces will be required to do this effectually—viz., two pieces 3⅝ inches long by 1½ inches wide, shaped as in Fig. 29, to fit against the inner faces, and one piece 6 inches long, by ¾ of an inch wide, to wrap round the web. Particular care must be taken that every portion of the inside of the armature's channel be entirely covered in silk. When this has been satisfactorily performed, another coat of Brunswick-black may be given (avoiding to soil the outside), and the armature allowed to dry thoroughly in a warm oven.

§ 32. Our dynamo is now ready for wiring. For this purpose we shall require about 7 lb. of No. 16 single cotton-covered copper wire for the field-magnets, and about ½ lb. No. 20 double silk-covered for the armature. The amateur should be careful to get *new* wire, of the highest conductivity, and very soft; the employment of old, kinky, and hard wire is fatal to success.

§ 33. The quantity of wire above mentioned having been duly selected, it should be tested for continuity. The No. 16 will give evidence to the sight alone, whether there be any break in it or not. Should there be such, the covering from the two broken ends should be uncovered for about an inch on each end, the two extremities filed down to a fine flat wedge, so as to fit one another, when each one separately should be warmed for a second over the flame of a spirit-lamp, dipped into powdered resin, and rubbed, while being held in the flame of the lamp, with a rod of solder, until each has taken a good coating of solder. The two ends may then be applied with their flattened portions together over the flame of the spirit-lamp until the solder coating melts. Keeping the ends pressed together, the wire is to be removed from the flame. The solder soon hardens, and the wires will be found firmly united. It is now only necessary to file away any roughness, and rewind the cotton covering over the

bared portion, adding a little darning-cotton if the covering be deficient. The finer wire, which is generally bought on reels, had better be tested with the galvanometer (Fig. 2). To this end, find the two extremities of the wire, attach one to one binding-screw of the galvanometer, the other extremity being in good metallic contact with the pole of any single-cell battery. Connect the other pole of the battery with the other binding-screw of the galvanometer. An immediate and large deflection of the needle will show that the wire is continuous. If not, the wire must be unwound from the reel, and carefully wound on to another until the point at which the break occurs has been discovered. The two broken ends may be joined as described above, great care being taken after joining to recover the point of junction thoroughly, so as to preclude all danger of leakage, more silk being used to this end if necessary. It having been ascertained that the wire is perfect and in good condition, the next step is to soak it in melted paraffine wax, The good effect of this is twofold: (*a*) The insulation is thereby rendered very much better; (*b*) a damp atmosphere has then little or no effect on the insulation, since the paraffined cotton and silk covering is no longer hygroscopic, and may actually be pumped upon without becoming wetted or spoiling the insulation. To paraffine nicely the wire should be laid in a shallow dish large enough to contain it easily—a circular tin baking dish will do admirably. It should then be placed in a warm oven, not too hot, until it is about the heat of the hand—say, 90° Fahr. About ½ lb. of good paraffine wax should now be placed in the tin, and the oven closed until the paraffine is all melted. The wire may then be turned over two or three times until it is seen to be thoroughly soaked with the paraffine. Two or three metal rods should now be placed across the top of the dish, on which the wire may be placed to drain for a few seconds while still in the oven. When it ceases to drip it may be removed from the oven and allowed to cool. The superfluous paraffine, while still hot, may be poured into a cup (which has been just previously breathed into) to set, when it may be used for other insulations.

§ 34. Winding the armature next claims our attention. Having marked the heads, so as to know which belongs to a given extremity of the armature, we unscrew and remove them; about 6 inches of the extremity of the No. 20 wire should be coiled tightly round the end of a pencil, so as to

form a tight helix from which the pencil must then be slipped out. This helix will form one of the spare ends of the wire which will be attached to the commutator, and should be, for the time being, tied with a bit of silk to the outside of the armature, so as to be out of the way while winding. Holding the armature in the left hand, with the end which corresponds to the commutator facing us, and beginning at the left-hand cheek, we wind the wire in the channel, continuing to wind until we reach the right-hand cheek, taking care to lay the wire on as closely as possible, never allowing it to ride over its neighbor, nor yet to leave gaps between. When one layer has thus been carefully wound on, as shown at Fig. 30, it should be tested for insulation, since the amateur is very apt to wind carelessly and cut the insulating covering, either by catching in the sharp corners of the channel or otherwise. To test for insulation, tie the end of the wire (without detaching it from the reel or hank) against one cheek of the armature, to prevent its unwinding during the trial; then connect one pole of a battery to one binding-screw of a galvanometer, and the helix end of the wound wire to the other binding-screw. On touching the iron of the armature at any point with the other pole of the battery, *no deflection of the needle should take place*. Should a deflection show itself, evincing a metallic contact and want of insulation at some point, the wire must be unwound, the flaw localized and remedied by a fresh covering of silk, basted with paraffine, and again wound on and tested until the insulation is satisfactory. A layer of thin paraffined paper should now be laid over the first layer of wire, and the winding proceeded with in exactly similar manner, until the second layer has been laid on, remembering that the essentials of success are to wind the wire as closely as possible in each layer without overlapping; to avoid grazing the covering of the wire, so as to maintain insulation, and to wind always in one direction—viz., *from us, over to under*. There is no necessity (when using silk-covered wire) to place a stratum of paraffined paper between each layer of wire, as this, by increasing the distance between

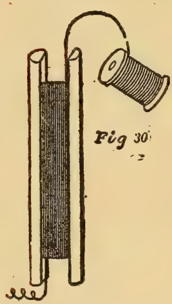


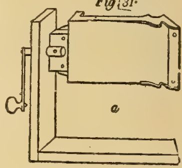
Fig 30

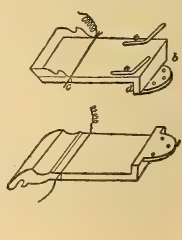
the layers, somewhat decreases the efficiency of the machine; this is only advisable when the insulation of the wire has been found to be imperfect. The winding should be proceeded with, layer after layer, evenly, tightly and smoothly, until the wire just fills the channel. Care must be taken that it does not exceed this, for if it comes higher than the cheeks it will surely catch in the limbs of the field-magnets during rotation. From eight to nine layers of wire may be laid on, according to the tightness with which it is pulled during winding. When the due proportion of wire has been laid on, it should be fastened down by tying, so as not to unwind, with its free end at the same extremity (the commutator end) as we started from. The helix may now be straightened out, and its condition observed, to insure that it is well insulated. The end at which we finished winding should also be straightened out and examined for good covering Then a stick of elastic glue should be heated and rubbed over the covered ends right up to the armature, so as to thicken them to such an extent that they will only just pass through the holes bored in the head to which the commutator is attached. (See Fig. 18, *c*, *c*.) The wire ends should be passed one through each of these holes (care being taken that the head be put on as it was previous to removal), pulled pretty tightly, but not so roughly as to graze or injure the covering, and having been cut so as to just reach the heads of the screws, which fasten the two halves of the split tube of the commutator to its cylinder (see Fig. 25), should have their extreme ends unwound and cleaned, and then be soldered down, one to each half of the split tube, care being taken that neither the solder nor the wire passes beyond the line of the screws; so as to leave plenty of room for the brushes to press against the commutator. The heads may now be screwed up in their place, and a coat of good sealing-wax varnish (best made by dissolving good scarlet sealing-wax in methylated spirit) painted over the layers of wire, both for the sake of appearance and to keep the wires from moving out of place during rotation, though if the wires are tightly wound this would be hardly needful. This coat of varnish must be allowed to dry off in a warm atmosphere (not in the oven), and the armature will be complete.

§ 35. Our labors are now drawing to a close. To wind the field-magnets it will be as well to rig up a little piece of

apparatus, since, although they may be wound without, it is very difficult to lay the wire as closely, as tightly, and as neatly as can be done by its aid; and since the efficiency of the machine is greatly exalted by the greater proximity of the wire to the core, it is a matter of considerable importance that this should be attended to. The apparatus necessary consists of a handle fastened to an axle passing through a standard supported on a base; the axle having a prolongation to which each limb of the field-magnets can be screwed down in its turn. On turning the handle, it is evident that the iron mass of the field-magnet will rotate on its axis, and if care be taken that the center of the mass coincides with the center of motion, the motion imparted to the iron will be smooth and even, and the wire may be laid on with great exactitude and closeness. This apparatus is illustrated at Fig. 31, *a*, with one of the limbs of the field-magnets screwed in its place, ready for winding. It should be made out of ¾-inch stuff, the base being about 5 inches wide by 6 inches long. The upright through which the axle passes should also be about the same size, and screwed to the edge of the baseboard. so as to stand at right angles to it. A short piece of broomstick, about ¾ of an inch in diameter, may be used as the axle, and a hole must be bored in the upright, at about 4 inches from this base, to admit this axle. To the external portion of the axle is fastened a handle; while to the internal portion, which should protude about 1½ inches, is screwed a piece of ½-inch stuff about 1½ inches square, half the axle being cut away to admit of its lying flat. Previous to screwing down, the handle, as well as this latter square piece, should be rubbed over with a little good hot glue at the places where they touch the axle, to insure a good sound joint. This "winder" being completed, it may be clamped to a bench or table by means of a sewing-machine or fretsaw clamp, the leg of the field-magnet having been previously screwed to it by means of the three holes in the flange, in the position shown in the figure. Though shown in

Fig. 31.





the cut to the *left*, the handle of the winder should be to the *right* of the operator, unless he be left-handed. In commencing to wind the wire, the operator should stand over his work, a sheet of paper having been placed on the floor, and the coil of paraffined wire at his feet, with a two-gallon stone bottle filled with water, to keep the bottle from upsetting, in the center of the coil to prevent its tangling or kinking. The surface of this jar being glazed, the wire slips from it without injuring the covering. The winding should be commenced at the extremity farthest from the handle—that is, nearest to the *channel* in the field-magnets in which the armature rotates. Six or eight inches of the wire should be coiled round a pencil, and so as to form a tight helix, which, with a piece of strong twine, should be tied to the leg of the magnet, as shown in Fig. 31, *b*. Holding the loose end of the wire in the left hand, keeping it pretty tightly pulled, and straightening it out from its coiled shape as it passes through the fingers, it is easy in this manner to wind the wire perfectly flat and smooth by turning the handle of the winder in the direction of the motion of the hands of a watch. (In order to prevent any accidental contact though abrasion against the corners, etc., it is advisable previously to cover the legs of the field-magnets, at all events as far as the wire is to extend—viz., from *c* to *d* in the present figure—with a band of silk dipped in melted paraffine, and applied hot to the iron, when it will immediately adhere. This band must be carefully smoothed down, so as not to cause unevenness in the winding of the wire.) If the wire be nicely laid on, it will be found possible to wind forty rows between *c* and *d*. Before arriving at *d* it will be necessary to place two pieces of tape about ½ an inch wide and 3 inches long, as shown at *e e* in the figure, the free ends of which must be turned back smoothly and tightly over the layer just put on when *d* is reached. Continuing the rotation of the handle in the same direction, another layer of wire is now laid over the first; by holding the ends of the tape fast while beginning to wind this second layer, all tendency of sinking into the layer beneath, which may be displayed by the second layer, is overcome. Without this precaution it is almost impossible to prevent the outer layers of wire sinking into the interspaces of the layers below. Continuing in this manner, layer after layer should be laid on until seven layers have been wound, remembering to use tapes toward the end

of each layer, and that each layer will diminish by two rows. When the seven layers have been laid on, the wire must be tied down to the magnet to prevent uncoiling, and cut off from the hank of wire, leaving about 6 inches free for attachment.

In exactly a similar manner as regards attachment, direction of winding, etc., must the second limb be wound. The only difference that need be made is that, for convenience of having both ends of wire at the same end of the dynamo, it will be well to fasten the beginning of the wire (the helix) to the inside of the leg instead of to the outside. Fig. 31, *f*, will make this clear.

§ 36. Both for the sake of appearance and to further protect the insulation from damp air, etc., it is advisable to give the wires on the limbs of the field-magnets a coat of good varnish. The best for this purpose is made by mixing about 2 ounces of the best red lead with ½ an ounce of good *white hard* varnish. The two should be well incorporated together by working with the brush intended to be used for laying on the varnish.

The varnish should be applied in a thin layer with a soft brush, so as to disturb the paraffine coating as little as possible, since if the paraffine mixes with the varnish, this latter *never dries*, but remains a sticky mess. For this reason the coating of varnish should be allowed to dry without the application of heat, which, if the "white hard" be good, it will do in about eight to twelve hours. A second coat may be given if desired; but as this generally fills up the interstices between the layers of wire, it detracts somewhat from the neatness of the appearance.

§ 37. The varnish being *quite dry*, the dynamo may again be put together, care being taken that the parts are adjusted in the position which they occupied after fitting. If this has been properly done, the armature ought to turn freely in its bearings *quite close* to the limbs of the field-magnets, but without catching anywhere.

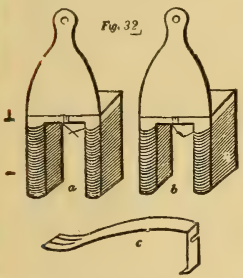
Supposing this to be all right (and it must be so, or the dynamo cannot work properly), the dynamo must be screwed down to a baseboard, which should consist of a slab of oak, walnut, or mahogany, 10 inches long by 8 inches wide, and at least 1 inch thick. The two holes in the lower flange in the limb of the field-magnets, near the channel in which the armature revolves, are expressly for the purpose of clamping

the dynamo to its baseboard. The baseboard should be chosen of a well-seasoned nature—polished, for appearance sake; and the dynamo should be screwed to it centrally, with the narrowest portion of the dynamo parallel with the narrowest portion of the baseboard.

Attachment of the Wires.

§ 38. The dynamo having been wound as described (and care must be taken to have fulfilled the instructions exactly, or else the resulting magnet will have two *north* poles, or two *south* poles, instead of one north and one south), we can proceed to couple up the various parts. To this end we begin by joining the wires at the two extremities at which we *left off winding*. This may be effected by removing a portion of the covering of the wires (by scraping with a sharp knife) for about an inch along the places where the two wires cross each other if made to touch. (See Fig. 32 *a.*)

Fig. 32



The wire must be made quite bright and clean by rubbing with a bit of sandpaper at this point, and then the wires are twisted tightly together by the aid of a pair of pincers. A drop of solder, taken up on a hot soldering-iron and run along the twisted portion will insure the contact remaining good. The excess of wire should now be cut off from the twisted end with a pair of cutting pliers; the bared twist bound round with a layer of darning-cotton, varnished with the red varnish (§ 36), and turned in out of the way between the limbs of the magnet. (Fig. 32, *b.*)

We may now proceed to magnetize the field-magnets. For this purpose we need only attach the poles of a single-cell bichromate battery, exposing from 8 to 10 square inches of negative surface, to the wires of the dynamo for a few seconds; but in order to obtain results which may be deducible from reason, and which can be corrected if mistakes are made, it is desirable to determine beforehand which shall be the north pole of our future magnet. It will be remembered (§ 8) that we have it in our power to produce a north pole, *to our left*, in a mass

of iron, by passing a current of electricity *away* from us, *over it;* and if we wish to produce a north pole to the *right*, the current must come *toward* us, over the mass.

Let us decide to make a north pole of the limb on which we began to wind the wire on the *outside*. (See Fig. 31, *c*.) To do this the current ought evidently to flow *from* the limb of the magnet *to* the observer; in other words, this wire must be attached to the negative pole of the cell. (The negative pole of the bichromate cell is the wire proceeding from the zinc, the one attached to the graphite being positive.) The positive pole of the cell must be coupled to the other wire, that is, the one which was started from the *inside* in winding. (See Fig. 31, *f*.)

While the battery is thus coupled up to the dynamo, we can test if we have produced the effect desired by bringing a suspended magnetized needle near the supposed north pole of the dynamo. If all has been properly performed, it will be found to attract the south pole of the poised needle, and repel its north pole,

A few seconds' connection with the battery will impart as much magnetism to the field-magnet as it will retain; but that little will be sufficient for our purpose. Our next step is to discover in which direction the current flows in our armature, when we rotate the fly-wheel in the usual way with the right hand (in the direction of the motion of the hands of a clock). Before we can do this we must fasten two "brushes" or collectors on the brush-blocks, in order to collect the electricity generated by the revolution of the armature.

The Brushes.

§. 39. These consist of two pieces of springy sheet brass, $\frac{1}{32}$ of an inch thick, 3¼ inches long, and about ⅝ of an inch wide. They must be bent twice at right angles, so as to fit tightly on to the brush-blocks (§ 28, Fig. 26), and slightly curved inward at the longer portions so as to press with some force against the commutator. (See Fig. 32, *c*.) To fasten these on to the blocks, a lateral slot is cut about half-way into each brush, at about ⅓ of an inch from the longest portion, of such a width as to admit the shank of a small screw passing into it. The portion of the brush which rests against the armature should be slit into two or three divisions, and curved slightly upward to avoid scratching the armature.

These two brushes, though alike in shape, must be put in opposite positions on the dynamo; that is to say, the one which goes on the block to the right of the observer has the longer portion above the block, while the one which goes on the left-hand block has the longer portion below the block. Thus the commutator is rubbed by these two brushes at diametrically opposite points. Care must be taken that the two screws which serve to fasten the brushes to the blocks do not touch the metal of the bolts which clamp the bearings to the dynamo, for if they did the current would short-circuit, and the machine would not work. It will also be necessary to observe that sufficient curvature be given to the longer portion of the brushes to clear the bearings altogether, otherwise, of course, the current would pass into the bearings and be short-circuited. Fig. 33 shows the brushes in their proper position; *a*, *a* being the commutator (exaggerated in size somewhat to show its position), *b*, *b* the brush-blocks, *c*, *c* the brushes, and *d*, *d* the screws which, by being tightened or loosened, can increase or decrease the pressure of the springs on the commutator, and to which the two wires which form the electrodes of the commutator are to be attached. These two wires, which in our machine may be about 3 inches long, with a loop at each end, as shown at Fig. 34 *a*, should be of No. 16 cotton-covered copper wire, the covering being removed from the two loops, which must be made quite bright. Before putting in the screws *d*, *d*, Fig. 33, each one should be passed into one eye of one of the said wires, then screwed partly into the brush-block, when the brush itself may be pushed into its place over the block, and under the screw, the slot in the side admitting of this; lastly, the screw is tightened up until the desired pressure on the commutator is obtained.

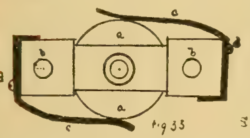


Fig 33

Fig 34 A

Fig 34 B

Fig. 34 shows the position of the wire, screw, and left-hand brush on the left-hand block. The two free ends of the wires just described project straight forward to the front of the machine; they may be screwed down on the baseboard, at the distance of about 3 inches apart, by means

of a small pair of binding-screws; the long screws of which are passed through the free eyes.

We can now test the direction of the current in our armature. To do this we place the fly-wheel on its bracket, put a leather band (such as is used for treadle sewing-machines) round the fly-wheel and driving pulley, then by means of two thin wires, which we will screw into the holes of the binding-screws just arranged, we couple up the brushes to our galvanometer (§ 3), and rotate the handle of the fly-wheel gently, in the direction we intend to work the machine for the future.

A deflection of the north pole of the needle, either to right or left, shows us in which direction the current is traveling; we carefully note, and mark with a paper label, which is the binding-screw which is sending the positive current (which if coupled to the wire *over* the needle, causes the north pole to turn to the left), since this is the binding-screw which must substitute the positive pole of the battery, and to which we must attach the wire which comes from the S limb of our dynamo.

§ 40. Two binding-screws are now to be inserted into the baseboard, to which the wires proceeding from the limbs of the field-magnet must be clamped. These should be placed about 1½ inches from he side of each limb, the wires proceeding therefrom being denuded of their covering and sandpapered at the extremities where they are clamped to the binding-screws. These binding-screws (as also those connected with the brushes) should, for the convenience of being able to couple up at one and the same time two or more wires, be of the pattern shown at Fig. 35, in which case the extremities of the field-magnets may be also formed into rings, as shown at Fig. 34*a*, and either clamped down to the baseboard by passing the long screw *c* (Fig. 34) into the ring, or the nut *a* having been removed for the time being, the ring may be slipped over the screw *b*, and then clamped by the nut *a*.

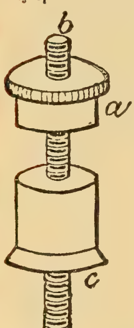


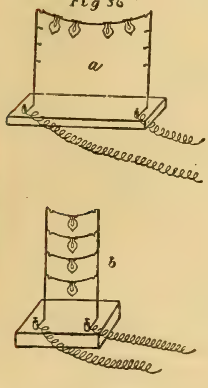
Fig. 35

Connection is now to be made between the binding-screw attached to the current-sending or positive brush (the one

which we have marked with a paper label), and the binding-screw coupled to the wire, starting from the *inside* of the limb of the field-magnet (see Fig. 31, *c*) by means of a short length of No. 16 copper wire, well cleaned, bent into rings at the ends, and clamped down as advised above.

If all the instructions have been carefully carried out, more especially those contained in the last six paragraphs, we shall find that on rotating the flywheel a powerful current will flow between the two remaining binding-screws—viz., the one connected with the outside wire of the field-magnets, and the other with the negative brush of the commutator—a current which will be sufficient to heat to bright redness 4½ inches to 5 inches of No. 42 platinum wire, or to light four 5-candle power lamps, arranged in parallel arc.

Fig 36



The current actually flowing through the circuit (the number of ampères) will naturally depend largely on the resistance interposed between the poles—that is to say, between the binding-screws connected with the outside wire of the field-magnet, and the negative brush of the commutators respectively; and since the magnetism of the field-magnet depends entirely on the amount of current flowing around it, and this again influences the current set up in the armature, it is evident that every variation in the resistance or the interpolar or outside circuit will produce a corresponding variation in the current, if the dynamo be connected up as above described; and that a very much larger current will traverse the circuit when the resistance is small than when the resistance is great. When the machine is doing its best work—that is to say, when the resistance of the interpolar is equal to the internal resistance of the machine—the current is equal to that of eight or ten Bunsen's cells against an equal resistance. Sometimes it is necessary to send the current through a greater resistance; in this case, in order not to weaken too greatly the magnetism of the field-magnet by diminishing so

greatly the current, it is necessary to shunt off a portion of the current, and send it round the limbs of the field-magnet by another circuit, which diminishes the total resistance.

To render this clearer, let us suppose that we wish to light up four five-candle lamps, having each an approximate resistance of eight ohms, and requiring a current of about one ampère each to cause them to give out their proper light. If we arrange them in series, as in Fig. 36, *a*, when the total resistance is the sum of their separate resistances = thirty-two ohms, then, as the electromotive force of our machine when at best is about ten volts, so $\frac{10}{32}$ represents the current flowing through the lamps, supposing even that the dynamo lost no power by the diminution of current (which it does to a very great extent), and this current is not sufficient to light the lamps. But if we arrange the lamps in parallel arc, as at Fig. 36, *b*, then the total resistance falls to a quarter of one single lamp—that is to say, it is equal to two ohms only; hence the currrent now flowing becomes $\frac{10}{32} = 5$ ampères, and this divided among the four lamps gives $1\frac{1}{4}$ ampères each, which is ample.

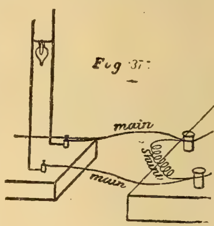


Fig. 37.

Again, we find that coupling up one single lamp to the dynamo presents too great a resistance, so that no light is given off, since not sufficient current can pass round the field-magnets to give an electromotive force of ten volts. But if we insert a "shunt," consisting of about a dozen inches of No. 30 iron wire between the two binding-screws aforesaid, as shown at Fig. 37, and then connect the lamp also to the said screws or terminals, more current circulates round the field-magnets, since two roads are now open to the current, the field-magnet becomes more powerfully magnetic, and in its turn induces a much more powerful current in the armature, and so on until current enough is produced to

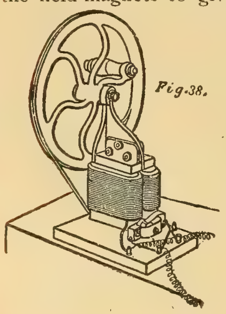


Fig. 38.

light up the lamp. The resistance of the "shunt" to be inserted between the terminals, to produce the best result, will depend on the resistance of the interpolar. If this latter be low, no "shunt" (or one of very great resistance) will be required; but if the resistance of the interpolar be very high, the resistance of the "shunt" must be correspondingly low, or else not enough current will pass to magnetize the field-magnet, and the dynamo will give no current.

Fig. 38 represents the dynamo complete.

The machinist, mechanic, engineer, artisan, student or schoolboy who has not only carefully read the preceding pages on the dynamo, but has made, or attempted to make, a machine by closely following the instructions, will have acquired a knowledge of the rudiments of electrical science which will enable him to explore still further into this fascinating branch of the mechanical arts. This book is merely designed to start the explorer on his interesting journey; new discoveries, new inventions, and new surprises are daily events in the electrical world; but, the fundamental principles, the foundation laws, never change, and, with a fair understanding of the underlying structure, the growing fabric can be watched with satisfactory understanding.

The wide-awake mechanic will endeavor to keep abreast with the times. He will be quick to note any novel discovery, any important innovation, and in no branch of his art are the possibilities of world-thrilling sensations greater than in the electrical field.

Suppose, then, that you have made a dynamo, such as described in this article; suppose that you have it in active operation, and it is giving you a current equal to eight or ten Bunsen's cells; you have an instrument which will be of the highest value to you in your future researches; instead of finding the study a laborious grind, a dry, musty, brain killer, you will find yourself fascinated with the opening pages of the mysterious book when it is read by the light of the electrical current generated by the dynamo made by the skill of your own hands.

Too much value cannot be given a knowledge of the science of electricity and its application to the mechanical arts, increasing every day, will bring it in contact with every mechanic and artisan in the country. Make a dynamo as described, study as you make, and you will be able to keep abreast of the times.

MANAGEMENT OF DYNAMOS.

The use of dynamos is becoming so general for electric lighting and power that the following hints on the management and care of dynamos may be of use to engineers, especially as the care of the dynamo is usually placed in the hands of the engineer, and the machine placed in the engine-room.

Before the dynamo is started for its day's run all the lubricators should be filled up. For this purpose none but copper oil-cans should be used.

Next in order, the brushes should receive attention, and should be carefully examined to see that they are properly trimmed and thoroughly well screwed up to their holders.

If the brushes touch at a bevel angle, they should be occasionally trimmed with a file, so that they will preserve an even bearing upon the commutator. To do this properly the brushes should be removed from the machine.

Never leave files or iron tools near the dynamo. If the machine is in a shop where iron filings are flying about it should be examined frequently to see if any filings have been attracted, and if any are found they should be removed. It is always best, if the dynamo is of necessity placed in such a position, that it should be boxed in as completely as possible.

After the machine has been started the brushes should be put down; when the run is over the brushes should be raised *before* the engine is stopped.

The commutator *must be kept clean and bright* and free from metallic dust of any kind. It should be occasionally wiped with a *clean* rag (never use waste), very slightly smeared with oil or vaseline; should the brushes press too heavily it will be worn into ruts, should they not press firmly enough its segments will wear unequally along their edges.

As soon as the dynamo is started the brushes should be carefully so rocked that they touch at the neutral points; if this position is not carefully observed the sparking may rapidly ruin the commutator.

ELECTRICITY SIMPLIFIED.

No one knows what electricity really is. It seems, however, to be present everywhere. In the air, in the earth, in the water, in trees, animals, man, fishes, metals, everywhere, but no one can tell *what* it is, We know what steam is, for we can divide it into its various parts. We know what a gas is, for we can smell it, or taste it, or weigh it. We know what the air is; but we cannot see electricity, it has no taste, it has no weight, no substance, but it is called a force, which is made known to us by the peculiar fact that it will attract or repel.

For instance, if you take a piece of glass — a small glass rod or tube, and a piece of sealing-wax, and bring them near some small scraps of paper, or shreds of cotton, a feather, or gold leaf, or bran, you will not notice anything particular. There will be no movement of any kind. But, suppose you rub the glass and the sealing-wax briskly with a piece of dry woolen cloth, then bring them near the light substances mentioned, you will find that the paper, or cotton, or gold leaf, or bran, or feathers, will spring or jump toward the glass rod or sealing-wax, even if quite a little distance is between them, and will cling to the glass and wax.

You will further notice, that, after a time, the paper, etc., will jump away (not simply *fall*) from the glass, or wax, as if they had been snapped off.

Thus, there was *something* happened when the glass or wax was rubbed by the woolen cloth, *something* which gave the glass or wax the property of *attracting* the paper, etc. and afterward of *repelling* or *casting off* the same paper, etc.

This *something* was the *electricity* excited by the friction between the glass or wax and the woolen cloth.

The writer of this article is smoking an ordinary pipe, which has an amber mouth piece. He first wiped the moisture from the amber, and then rubbed it for a few seconds upon the green cloth of his desk, and, bringing it near some little bits of paper, he found that the paper sprang and remained upon the amber, and, not only that, but the bit of paper next to the amber attracted another bit of paper, and that second piece another, until three little bits of paper, like a chain, were hanging from the amber.

First, the amber was electrified, then each bit of paper, as

it came in contact with the electrified amber, became electrified, and attracted another bit to itself. Now, there are two kinds of electricity, *positive* and *negative*. The positive attracts and the negative repels. This last statement can be easily proved. Make two little balls from the pith of the elder bush, or any other plant that has a dry, light pith. When quite dry, fasten a fine silk thread to each pith ball, and suspend them from some convenient point so they will swing freely.

Electrify the sealing-wax with the woolen cloth, but, electrify the glass rod with a piece of soft silk. Touch one pith ball with the wax, and it will follow it for a moment and then shoot away, just as the paper did. At the same time touch the other pith ball with the glass and it will do the same thing. If you bring the wax and glass nearer the pith balls after they have been repelled, you will notice that they will keep away from them. Now quickly change the wax and glass, so that they will touch the pith ball that was first attracted and then repelled by the glass, and you will see that the wax will attract it, and, if you touch the other pith ball with the glass, it will be attracted also.

If you have taken the trouble to try this simple experiment, you have learned that there is a *positive* electricity, or the electricity that attracts, and a *negative* electricity, or the electricity that repels.

You have also learned that the ball which was repelled by the glass was *attracted by the sealing-wax*, and the ball that was repelled by the sealing-wax, was *attracted by the glass*. This proves that the electricity developed on glass *is different in kind from that developed on sealing-wax*, and by repeating the experiment with other substances, it will be found that *all electrified bodies act like either the glass or the sealing-wax*.

There is another thing, two bodies charged with (or having) *positive* electricity will repel each other, and the same thing will happen if the two bodies are charged with *negative* electricity, but, if one is charged with *positive*, and the other with *negative* electricity, they will be attracted to each other.

The electricity which is excited by *rubbing* two substances together is called *frictional electricity*.

It has been shown by the above experiments that an *electrified* substance can impart electricity to another. This is called *conduction*. It is not necessary that the bodies should

touch. They may be connected by a copper wire or a flax thread. But, if connected by a silk thread, or a piece of rubber, the electrified body will not electrify the other. *Some substances transmit electricity readily and others do not.*

Those that offer little resistance to the passage of electricity are called *conductors;* those that offer great resistance are called *non-conductors* or *insulators.* Conductors which are held up, or wrapped in *non-conductors* are said to be *insulated.* Silver, copper and iron are *conductors.* Rubber, gutta-percha, glass, porcelain and silk are *non-conductors* or *insulators.* A copper wire, if wrapped in silk or rubber, would be insulated.

For practical work, conductors are made of wire, either copper or iron, usually having a covering made of woven silk or cotton.

Frictional electricity is generated, for purposes where a large quantity is needed, by *electric machines,* which consists of a circular glass plate from one to four feet in diameter, that is turned by a crank. Against the sides of this plate are cushions made of silk or leather, coated with mercury. On turning the crank, the glass plate revolves between the silk cushions and is electrified. The electricity is gathered or caught by metal points called combs, and is carried off by conductors.

Electricity is also developed by *chemical action.* All chemical changes produce electric action. This is true whether the substance is a solid, liquid or gas; but the chemical action between liquids and metals gives the most satisfactory result. Electricity thus developed is called the Voltaic or Galvanic electricity. As was said before, we do not know just what electricity is, but we do know that by combining certain liquids and metals, or by making certain chemical combinations, we can make all the electricity we want.

If we take a strip of copper and one of zinc, and place them in a glass jar which contains some dilute sulphuric acid (that is, water which has had sulphuric acid put in it), keeping the zinc and copper separated, but connecting them *above* the glass jar by a wire conductor, we will have a current of electricity produced. In fact, *two currents*, opposite in kind and direction, are produced—but, remember that, whenever the *direction* of the electric current is referred to, it means the direction of the *positive* current.

It is necessary, for the production of an electric current in

this way, that the liquid should have a greater action upon one metal than upon the other. The metal which is most vigorously acted upon by the acid is called the *positive* plate (it *generates*, one might say, the electricity), the other is the *negative* plate (it *collects* the electricity). So the current starts from the positive plate, through the liquid to the negative plate, then out of the glass jar through the wire joined to the negative plate, and back through the other wire to the positive plate. In the apparatus described above (called a galvanic or voltaic element or cell) the zinc is the *positive* plate, copper the *negative* plate.

The wires attached to the copper and zinc are called *electrodes* or poles. The electrode attached to the copper plate (which is the negative) is called the *positive electrode*. The one attached to the zinc plate (which is the positive plate), is called the *negative electrode*.

When two or more voltaic or galvanic elements (or cells) are connected together, the apparatus is called a galbanic or voltaic battery. In a battery the positive plate of one cell is connected to the negative plate of the next cell, and so on. When this is done, they are said to be coupled in series. Sometimes all of the positive plates are connected by wire, and all of the negative plates by another wire. The cells are then said to be joined in "multiple arc."

Batteries for producing electricity are divided into two classes, called "open circuit" batteries, and "closed circuit" batteries. The open circuit batteries are used when the electricity is *not* required *constantly*, but is used for a short time at different periods. Such batteries are used with telephones, electric bells, hotel annunciators, etc.

Closed batteries are used where the work is continuous, as for electric lights, motors, etc.

(As galvanic cells can be readily purchased, and are not expensive, it is recommended that a cell for open circuit and one for closed circuit be purchased. For open circuit buy one of the following makes: Leclanche cell, or the Law; for closed circuit, the Grenet. These cells can now be bought of any electric supply store).

Batteries as described, generating or producing electricity by the action and combination of chemicals liquids and metals, are called "*Primary Batteries*."

There is another style of batteries, called Secondary or **Storage batteries. A secondary battery does not of itself**

make an electric current, but is used to store up and hold the energy of an electric current, which is led to it from a primary battery or a dynamo. The electrical energy can then be kept until it is wanted for use.

A secondary or storage battery usually consists of a glass jar, holding plates, made of lead, and some water, which is made slightly acid. There are always two lead plates in a secondary battery, but there may be any number above that, and these plates are called electrodes. Upon the positive electrode is spread a paste made of red lead. Upon the negative electrode is spread a paste made of litharge.

When the plates are thus prepared, they are put into the acidulated water (which is held by the glass jar), and a wire from each plate is connected with conductors from a dynamo or a primary battery. When all is ready for charging, the current is turned on, and enters by one plate, coming out by the other.

The electric current, of course, meets with some resistance from the plate and the paste, and this resistance causes it to work upon the paste in such a manner that a chemical change is made, that is, the paste on the positive electrode has been changed to peroxide of lead, and that in the negative electrode into spongy lead.

When the current has passed from one plate to another in this way for a time, the wires are disconnected from the dynamo or primary battery.

As the acidulated water is still left in the glass jar, the paste upon the plates begins to work to get back to its original shape, and it is this working that causes a current of electricity, which will light lamps, run a motor or do anything the current from the dynamo or primary battery would do.

After the paste has resumed its original form, the battery is said to be discharged, and can then be again charged.

It is customary, in practical use of secondary or storage batteries, to charge them from a dynamo. These batteries are largely used for street car purposes. A motor is attached to the axle of the car, and is energized by the storage batteries placed beneath the seats, the batteries having been charged from a dynamo located at the terminus of the road.

In the article on "How to Build a Dynamo," commencing on page 478, the magnetizing effects of an electric current are explicitly explained.

Electricity, although it has no weight or tangible form, is measured as accurately as is steam, or air, or coal.

The three measurements most commonly used are

The Volt;
The Ampère;
The Ohm.

THE VOLT is the practical unit of measurement of *pressure.* That is, "*volt*" bears the same relation to electricity as "pounds" does to steam. When we speak of steam in a boiler or in the cylinder of a steam engine, we say: "There is a pressure of ten or fifty or a hundred pounds to the square inch," and steam pressure is calculated and measured in pounds; thus, a "pound" is the unit of pressure or intensity.

Now, electricity moves with a certain force and pressure; this force is called the electro-motive force (represented by the letters E. M. F.), and the unit of *pressure* or *intensity* of this force, is called a *volt.* Thus we say that a dynamo has an electro-motive force of 117 volts, or that the intensity of a galvanic cell is 1½ volts, etc.

Suppose, instead of steam, we had used the water which comes into the house from the water-works, as an illustration. That water comes in through pipes and is *forced* through these pipes by pumps.

Now, the water comes with a pressure of so many pounds to the inch, and "pound" is the unit by which this pressure is measured. The water would not flow through the pipes unless it was pushed or forced through, neither would electricity flow through the wires without there was pressure back of it, and this pressure is measured in volts.

THE AMPÈRE is the practical unit of *the rate of flow* of electricity. Electricity flows through the wire at a certain pressure, just as water flows through pipes at a certain pressure. Now, if we wanted to speak of the water coming through the pipes, we would say that the water was flowing at the *rate of* five gallons per minute, and if the pressure on the water was ten pounds, we would say that the water was flowing at the rate of five gallons per minute, at a pressure of ten pounds to the inch.

In speaking of the electric current, we say, "that a certain current of electricity is flowing at the rate of one *ampère*, acted upon by an electro-motive force of 90 *volts*, or a lamp requires a current of two *ampères*, at a pressure of 100 *volts* to light it.

Thus, the *volts* of pressure forces the current to flow through the wires at a certain rate per second, and this rate is called the *ampère*.

THE OHM (pronounced like "ome" in home) is the practical unit of measurement of *resistance*.

Electricity is conducted or carried from one place to another, for the purpose of telegraphing, telephoning, light, power, etc., by means of wires, made of copper or iron.

These wires do not permit the current to flow through them without hindrance. There is always a certain amount of *resistance* to the current, and the smaller the wire, the more *resistance* there is. Sometimes the current is too strong for the wire, and it becomes hot, gets red, and burns up.

That is, the wire is too small for the volts pressure, and ampéres of current of electricity, and the current, trying to get through, and fighting to overcome this resistance, becomes red hot and then may melt.

This *resistance* is measured by the *ohm;* thus, a copper wire of such a size has a resistance of so many *ohms*.

RULES AND REGULATIONS.

FOR

PROPERLY WIRING AND INSTALLING ELECTRIC LIGHT PLANTS.

The following rules and regulations for the prevention of fire risks arising from electric lighting, were issued by the Society of Telegraph Engineers and Electricians of England, and every person, connected with an establishment using electric lights, whether owners or employés, should carefully read them, and be governed thereby:

The chief difficulties which beset the electrical engineer are internal and invisible, and can only be effectually guarded against by testing with special apparatus, and electric currents. They arise from leakage and bad connections and joints, which lead to waste of energy and the production of heat to a dangerous extent.

MOISTURE DANGER.—The necessity for guarding against the presence of moisture, which leads to loss of current and to the destruction of the conductors and apparatus, by corrosion and otherwise, cannot be too strongly urged.

EARTH DANGER.—Injudicious connections of any part of the circuit with the "earth" tend to magnify every other source of difficulty and danger.

IGNORANCE AND INJUDICIOUS ECONOMY.—Many of the dangers in the application of electricity arise from ignorance and inexperience on the part of those who supply and fit up inadequate plants, and frequently from injudicious economy on the part of the user.

SAFETY IN CONSULTING EXPERIENCED ENGINEERS.—The greatest element of safety is, therefore, the employment of skilled and experienced electrical engineers to specify the method in which the work is to be done, and the quality of the materials to be employed, and to supervise the execution of the work.

CONDUCTORS.

1. SECTIONAL AREA.—Conductors (wires) must have a sectional area and conductivity so porportioned to the work they have to do, that, if double the current proposed is sent through them, the temperature of such conductors shall not exceed 150° Fahr.

2. ACCESSIBILITY.—The conductors, or their coverings, should be placed in sight, if possible, and they should always be as accessible as circumstances will permit.

3. INSULATING.—Within buildings they should be insulated; and this rule applies equally to all conductors and parts of fittings which may have to be handled.

4. MAXIMUM TEMPERATURE.—Whatever insulating material is employed it should not soften until a temperature of 170° Fahr., has been reached, and, in all cases, the material must be damp-proof.

5. CASINGS.—When wires pass through roofs, floors, walls or partitions, and where they cross, or are liable to touch metallic substances, such as bell wires, iron girders, or pipes they should be thoroughly protected by suitable additional covering; and, where they are liable to abrasion from an

cause, or the depredations of rats or mice, they should be encased in some suitable hard material.

6. DISTANCE APART.—Conductors should be kept as far apart as circumstances will permit, the spacing between them being governed by their potential difference.

7. INFLAMMABLE STRUCTURES.—When conductors are carried in very inflammable structures, precaution should be taken to isolate them therefrom.

8. METALLIC ARMOR.—Conductors which are protected on the outside by lead, or metallic armor of any kind, require the greatest care in fixing, on account of the large conducting surface which would become connected to the core in the event of metallic contact between them.

9. JOINTS.—All joints must be mechanically and electrically perfect, to prevent heat being generated at these points. When soldering fluids are used in making joints, the latter should be carefully washed and dried before insulation is applied.

10. GAS AND WATER PIPES.—Under all circumstances complete metal circuits must be employed. Gas and water pipes must never form part of a circuit, as their joints are rarely electrically good, and therefore become a source of danger.

11. OVERHEAD CONDUCTORS.—Overhead conductors, whether passing over or attached to buildings, must be insulated at their points of support.

Precaution must be taken to obviate all risks of short-circuiting, where they are likely to touch a building, or other overhead conductors and wires, either by their own fall or by being fallen upon by other conductors.

12. LIGHTNING PROTECTOR.—In the case of overhead wires, every main should have a lightning protector at each point, where it enters or branches into a building.

13. INSULATION RESISTANCE.—The insulation of a system of distribution should be such, that the greatest leakage from any conductor to earth (and, in case of parallel working, from one conductor to the other, when all branches are switched on, but the lamps, motors, etc., removed), does not exceed *one five thousandth part* ($\frac{1}{5000}$) of the *total current* intended for the supply of the said lamps, motors, etc., the test being made at the usual working electro-motive force.

SWITCHES.

14. CONSTRUCTION AND ACTION.—Every switch or commutator should be of such construction as to comply with the following condition, namely: That when the handle is moved or turned to or from the positions of "on" and "off," it is impossible for it to remain in any intermediate position, or to permit of a permanent arc, or heating.

15. INSULATED HANDLES.– The handles of every switch must be completely insulated from the circuit.

16. MAIN SWITCHES, POSITION OF.—The main switches of a building should be placed as near as possible to the point of entrance of the conductors, or to the generators of the current if they are within the building itself. Switches should be provided on both leads.

17. SWITCH BOARDS.—Switch boards should bear clear instructions for their use by the inexperienced.

ELECTRICAL FITTINGS GENERALLY.

18. BASES.—Switches, commutators, resistances, bare connections, lamps, etc., must be mounted on incombustible bases; cut-outs, mounted on bases of wood, rendered uninflammable, are admissible; vulcanite bases are undesirable in damp situations. The cracking of porcelain and earthenware fittings is a source of danger which can be avoided by precautions in fixing.

CUT-OUTS.

19. IMPERATIVE USE OF.—All circuits should be protected by cut-outs; and all leads from the mains, or small conductors from larger ones, must be fitted with cut-outs at their branching points

20. SITUATION.—Where fusible cut-outs are used, the section should be so situated within its frame that the fused metal cannot fall where it may cause a "short circuit" or an ignition.

21. FOR (+) AND (—) MAINS.—For all main conductors a cut-out should be provided for both the "flow" and "return;" and the two fusible sections must not be in the same compartment.

22. FOR PORTABLE FITTINGS.—The flexible wires of portable fittings must in all cases be protected by cut-outs at their fixed points of connection.

ARC LAMPS.

23. GLOBES, ETC.—Arc lamps must always be guarded by globes, netted or otherwise, so to prevent danger from ascending sparks, or from falling glass and incandescent pieces of carbon.

24. INSULATION OF PARTS.—All parts of the lamps and lanterns which are liable to be handled (except by the persons employed to trim them), should be insulated.

THE DYNAMO.

25. INSULATION, SITUATION, ETC.—The armatures and field magnet coils should be thoroughly insulated. Dynamos should always be fixed in dry places, and they must not be exposed to dust flyings or other industrial waste products carried in suspension in the air. They should not be per-

mitted in the working rooms of mills, where the liability to such dangers exists, or, where any inflammable manufactures are carried on, or inflammable materials are stored.

26. MOTORS.—Motors should be subject to the same conditions; but when it is necessary to use them in positions such as those above referred to, they must be securely cased in, such cases having a non-combustible lining.

BATTERIES.

27. INSULATION.—Both primary and secondary batteries should be placed and used under the same precautions as prescribed for dynamos; and the room in which they are placed should be well ventilated. The batteries themselves must be well insulated.

MAINTENANCE.

28. TESTING.—The value of frequently testing and inspecting the apparatus and circuits cannot be too strongly urged as a precaution against fire. Records should be kept of all tests, so that any gradual deterioration of the system may be detected.

29. CLEANLINESS.—Cleanliness of all parts of the apparatus and fittings is essential to good maintenance.

30. REPAIRS.—No repairs or alterations must be made when the current is "on."

GENERAL.

All the above rules for the reduction to a minimum of the risks from fire, are also applicable in principle to installations of electricity for other uses than that of lighting: they also include precautions necessary to avoid risks of injury to persons, whether the conductors and apparatus are situated inside or outside a building.

DEFINITIONS OF ELECTRICAL AND MECHANICAL TERMS.

A

ABSOLUTE TEMPERATURE.—Temperature as reckoned from the absolute zero, which is 461.2 degrees below the Fahrenheit zero.

ACCELERATION.—Rate of change of velocity.

ACCUMULATOR.—1. Any apparatus which increases the current strength, as a dynamo electric machine. 2. A secondary storage battery. 3. A condenser.

ACCUMULATOR, CHARGING.—Sending an electric current into a storage battery for the purpose of rendering it an electric source.

ACTION, LINES OF INDUCTIVE.—1. Lines of electrostatic force. 2. Lines within the space, separating a charge and neighboring body, along which electrostatic induction takes place.

ACTION, LOCAL, OF VOLTAIC CELL.—A waste of energy. Consumption of the zinc, or positive element of a voltai ccell, when the circuit is open or closed, or in regularly.

ACTIVITY, UNIT OF.—Rate of doing work. One unit of work performed in one unit of time equals one unit of activity. In C. G. S. system, unit of activity equals one erg per second. Practical unit in same system is the watt, equal to one joule per second. In British system, unit of activity is the horse power, equal to 550 foot-pounds per second or 33,000 foot-pounds per minute. The ratio between the two systems is 1 H. P. = 746 watts (about).

ADDENDUM.—That part of the tooth of a gear wheel which extends outward from and beyond the pitch line.

ADHERENCE, MAGNETIC.—Adhesion between surfaces due to magnetic attraction.

ADIABATIC EXPANSION OF A GAS.—The expansion when no heat is given to or taken away while so doing.

ADJUSTABLE REAMER.—A reamer the teeth of which may be adjusted to the necessary diameter.

ADMISSION.—Point of stroke at which steam is admitted to a steam cylinder.

ADMISSION LINE.—The line traced on an indicator card from beginning of stroke to point of cut-off.

AIR BLAST FOR COMMUTATOR.—A device to prevent the injurious action of destructive flashes at the commutator of a dynamo electric machine.

AIR PUMP.—The pump used to remove air and water from a condenser.

AIR THERMOMETER.—One generally made of glass tubing in which the expansion and contraction of a certain volume of air raises and lowers a column of water, and this, by a suitable scale, indicates the temperature.

ALLEN VALVE.—An ordinary D valve with an interior passage allowing steam to be admitted at two places.

ALLOYS.—A few of the more important combinations are:

Solder, plumber's; tin 66 parts, lead 34 parts.
Pewter, hard; tin 92 parts, lead 8 parts.
Britania Metal; tin 87 parts, antimony 8 parts, copper 4 parts, bismuth 1 part.
Type Metal; lead 80, antimony 20 parts.
Brass, white; copper 65, zinc 35.
Brass, red; copper 90, zinc, 10 parts.
Speculum Metal; copper 67, tin 33 parts.
Bell Metal; copper 78, tin 22 parts.
Aluminum Bronze; copper 90, aluminum 10 parts.
German silver; copper 50, zinc 25, nickel 25 parts.
Pailard Palladium; copper 15, palladium 60, iron 1 part.
Platinum Silver; platinum 1, silver 2 parts.

ALTERNATION.—A to-and-fro motion. Changes in the direction of a current.

ALTERNATIONS, COMPLETE.—A complete to-and-fro change.

ALTERNATIONS, FREQUENCY OF.—The number of alternations in unit time or per second.

ALTERNATOR.—An alternating current dynamo. A reversing commutator.

ALTERNATOR, COMPENSATED EXCITATION OF.—An excitation of an alternating current machine, in which the field is but partially excited by separate excitement, the remainder of its exciting current being derived from the commuted currents of the machine itself.

AMALGAM.—A mixture of metal with mercury applied to rubbers of frictional electrical machines.

AMMETER.—A form of galvanometer for measuring the current strength of amperes.

AMMETER, GRAVITY.—One in which a magnetic needle moves against the force of gravity.

AMMETER, MAGNETIC-VANE.—A fixed and a movable vane in the field, which repel each other and so measure the current.

AMMETER, PERMANENT MAGNET.—A magnetic needle moved against the field of a permanent magnet.

AMPERE.—The unit of electric current. That current which can be driven by the pressure of one volt, the unit of electromotive force, through one ohm, the unit of electrical resistance. Such a rate of flow of electricity as transmits one coulomb per second. A current of such strength as would deposit .005084 grains of copper per second. The unit rate of flow per second.

AMPERE FEET.—The product of the current in amperes by the distance in feet.

AMPERE HOUR.—Equal to one ampere flowing for one hour, or 3600 coulombs.

AMPERE-VOLT.—A watt or $\frac{1}{746}$ of 1 H. P. The following expression signifies that C, the current in amperes, is equal to E, the electro-motive force in volts, divided by R, the resistance in ohms: $C = \frac{E}{R}$. This is Ohm's law.

AMPERE'S RULE FOR CURRENT EFFECTS ON NEEDLE. A magnetic needle if placed near a current of electricity flowing from the observer, who is facing the needle, is deflected to his left.

ANEMOMETER.—An apparatus to electrically record the direction of the wind.

ANGLE OF LAP.—Angle through which eccentric must be turned to admit steam at beginning of stroke when the lap is added to a valve.

ANGLE OF LEAD.—Angle through which an the eccentric is turned to give lead to a valve.

ANGLE-TOOTH.—A gear wheel tooth which runs across the face of a wheel in a line that develops part of the circumference of the wheel.

ANNEALING.—The heating of metals, glass, etc., to a high degree and cooling slowly. To temper or soften.

ANNUNCIATOR.—A device for indicating the place at which electric circuits have been closed.

ANODE.—The positive terminal of an electric source, in opposition to Kathode, the negative terminal.

APRON.—1. In an iron planer, the piece that carries the tool post or clamp. 2. Applied to parts which act as a shield.

ARBOR.—A mandrel. A shaft or spindle.

ARC.—1. The source of light of the electric arc lamp. The bow of light which appears between two electrodes. An arc formed between two electrodes. 2. A section or part of a circle.

ARC OF APPROACH.—The arch (measured on the pitch circles) covered from the time any one pair of teeth of two gear wheels come into contact until the point of contact is on the line of centers.

ARC, COMPOUND.—An arc formed between more than two electrodes.

ARC OF PITCH.—The pitch of gear wheel teeth from measurement around the pitch circle.

ARC OF RECESS.—The arc (measured on the pitch circles) covered from the time the point of contact of any one pair of teeth of two gear wheels is on the center line, until they leave contact.

ARC, WATT.—The energy required to maintain a given arc or candle power.

ARM.—1. One of the paths of an electric balance. 2. A support for insulators carrying electric coils. 3. A movable sign employed as a signal on railroads.

ARM, ROCKER.—An arm on which the brushes of a dynamo or motor are mounted for the purpose of shifting their position on the commutotor.

ARMATURE.—The coils of insulated wire together with the iron armature core, on which the coils are wound. A mass of iron or other magnetizable material placed on or near the pole of a mbgnet. The iron sheathing of a cable.

ARMATURE, BI-POLAR.—An armature of a dynamo electric machine, the polarity of which is reversed twice in every revolntion.

ARMATURE, DRUM.—One in which the armature core is solid, or nearly so, the wires being wound longitudinally along the core and across the ends.

ARMATURE, NON-POLARIZED.—An armature of soft iron which is attracted, whatever the direction of the current.

ARMATURE, POLARIZED.—Having a polarity independent of that imparted by the magnetic pole.

ARMATURE, RING.—An armature, the coils of which are wound on a ring-shaped core.

ARMATURE, UNIPOLAR.—An armature, the polarity of which is not reversed during its rotation.

ASTATIC.—Standing, or possessing no direct power. Not opposed to the earth's magnetism.

B

B.—A symbol for internal magnetization.

BACK-GEAR.—The gears on the back of the head-stock of a lathe which can be thrown in or out to change the speed.

BACK-KNIFE GAUGE LATHE.—A lathe in which the work is finished and cut to desired shape by a knife at its back.

BACK PRESSURE.—Pressured caused on the back side of the piston by the exhaust steam.

BALL AND SOCKET JOINT.—A joint consisting of a ball in a socket which encases it, but permits it to be moved in the casing; a universal joint.

BALL-PENE.—The spherical pene of a hammer.

BAND-SAW.—An endless steel band having saw-teeth on one edge and run on pulleys like a belt.

BARS, OMNIBUS OR BUS.—The bars carrying the current from an electric generating plant.

BASTARD FILE.—A file, the teeth of which are coarser than those of a second-cut file and finer than those of a coarse-cut file, the difference usually being one grade or degree.

BATTERY.—The combination of a number of separate electric sources, as two or more voltaic cells or series of cells coupled together.

BATTERY, DYNAMO.—The coupling together of several dynamo-electric machines.

BATTERY, MAGNETIC.—The combination as a single magnet or a number of separate magnets.

BATTERY, OPEN CIRCUIT.—A battery through which the circuit is closed only when transmitting signals.

BATTERY, PLUNGE.—A number of separate cells connected so as to form a single source and be simultaneously placed or plunged in the exciting liquid.

BEARING.—A rest for a shaft or rod which holds it in position.
BELT-SHIPPER.—A shipper used to move a belt from one pulley to another.
BELT-TIGHTENER.—A pulley employed for tightening a belt on another pulley, and used to cause the belt to transmit power periodically instead of continuously.
BEVEL-GEAR.—A gear wheel whose teeth are at an angle to its shaft.
BLAST-PIPE.—A pipe conveyieg the air-blast to a cupola or other furnace.
BLOW OFF.—The opening generally at the lowest point in a boiler where the boiler is to be emptied.
BOARD, HANGER,—A supporting and connecting plate for arc lamps.
BOARD, SWITCH.—A board provided with switches which open, close or interchange circuits.
BOBBIN.—An insulated coil of wire for an electro-magnet,
BOILER STAYS.—Rods or bars or plates put in in such a way as to guy or stay flat surfaces to other parts.
BOILER, TUBULAR.—One containing a large number of small tubes through which gases from the fire pass.
BOILER, WATER TUBE.—One made up of a large number of small tubes in which water circulates.
BOLT.—Metal rod having a head on one end and a threaded stem to receive a nut at the other; used for holding.
BORE.—The inside of a cylinder.
BORING-BAR.—A bar that drives boring or cutting tools.
BORING-MACHINE.—A machine for boring holes in metal or other material.
BOSS.—A raised portion about a hole through which a bolt, screw, pin or shaft passes.
BOTTOMING-TAP.—A tap with a thread up to its extreme end so that it will cut a thread to the bottom of a hole.
BOURDON PRESSURE GAUGE.—The ordinary steam gauge in which the pointer is moved by the pressure acting inside a curved tube of elliptical cross section which it tends to straighten.
BOX-CHUCK.—A two-jawed chuck used in finishing brass.
BOX, DISTRIBUTION OR JUNCTION.—A manhole in an electric conduit at the junction of lead or other wires.
BOX-TOOL.—A tool for use in screw machines and turret heads which guides the work. It often carries more than one cutting tool.

BOX-WRENCH.—A wrench which fits endwise over the head of a bolt.

BRAKE, ELECTRO-MAGNETIC.—An electro-magnetic brake for car wheels.

BRAKE, PRONY OR FRICTION.—A mechanical device for measuring the power of a driving shaft.

BREAK OR GAP LATHE.—A lathe whose bed beneath plate is cut out out so as to permit work of large diameter to be swung.

BRIDGE.—An apparatus for balancing or measuring eletrical resistance.

BRIDGE WALL.—The wall just back of the grate of a boiler furnace reaching up close to boiler and causing flame to hug the boiler.

BRIDGE OF VALVE SEAT.—The thickness of metal between the exhaust and steam ports of a steam engine.

BRUSH.—Strips of metal, bundles of wire, plates of carbon, etc., that bear on the commutator cylinder of a dynamo-electric machine, and carry the current from and to it.

BRUSH LEAD.—The moving forward of the brushes in the direction of rotation to get the best output and reduce sparking.

BUCKLING.—Irregularities or bending of the plates of storage cells, sometimes due to a too rapid discharge.

BUNTER-DOG.—A work-gripping tool for a planing machine, consisting of a piece having a hook end to engage in the T-slot of the table and a set-screw to bind the work.

BUTT-JOINT.—A riveted joint in which the ends of the plate or material abut directly; distinguished from a lap or other form of joint.

BUTTON, CARBON.—A carbon resistance in the shape of a button.

BUTT-STRAP.—A band, usually of iron, for holding together the pieces in a butt-joint.

BUTT-WELD.—A weld in which the two pieces abut when put together to weld, as distinguished from a lap or other form of weld.

C

CABLE, CAPACITY OF.—The quantity of electricity required to raise a given length of cable to a given potential, or given difference of potential.

CALIBRATE.—To determine the relative value of the scale divisions or of the indications of a measuring device, as a galvanometer, voltmeter or ammeter.

CALORIC.—A heat unit.

CALORIMETER.—An instrument by which the amount of moisture in steam is determined.

CAM.—A disk whose surface is not a true circle, which actuates other parts by revolving.

CANDLE POWER.—The unit of photometric intensity. A light equal to that produced by a standard candle.

CAPACITY.—Such a capacity of a condenser or conductor that an electromotive force of one volt will charge it with a quantity of electricity equal to one coulomb.

CAP-SCREW.—A square-headed screw with a collar.

CARBONS, ARTIFICIAL.—Carbon obtained by the carbonization of a mixture of pulverized carbon with different carbonizable liquids.

CARBON, GORED.—A cylindrical carbon electrode for an arc lamp that is molded around a central core of charcoal, or soft carbon.

CASE-HARDENING.—A process for hardening the surface of wrought iron, the hardened surface being about 1-32″ deep.

CAT-HEAD.—A sleeve running in a bearing and screwed to light lathe work to steady it.

CAULKING.—The upsetting of the edges of the plates near riveted joints, thus making the joints tight.

CELL, BICHROMATE.—A zinc-carbon couple, in a solution of bichromate of potash and sulphuric acid in water.

CELL, BUNSEN'S.—A zinc-carbon couple, immersed respectively, the zinc in dilute sulphuric acid and the carbon in nitric acid.

CELL, DANIELL'S.—A zinc-copper couple immersed, the zinc in dilute sulphuric rcid and the copper in a sulphate of copper solution.

CELL, GRAVITY.—A zinc-copper couple in solution of zinc sulphate and saturated solution of sulphate of copper.

CELL, GROVE.—A zinc-platinum couple in sulphuric and nitric acid respectively.

CELL, LECLANCHE.—A zinc-carbon couple in sal-ammoniac.

CELL, POROUS.—A jar of unglazed earthenware, employed in double fluid voltaic cells, to keep the two liquids separate.

CELL, SELENIUM.—A cell consisting of a mass of selenium fused in between two conducting wires or electrodes.

CELL, SMEE—Zinc-silver couple in dilute sulphuric acid.

CELL, STORAGE.—A cell made of two relatively inert metal plates, immersed in an electrolyte, that stores electric energy when passed into it, and reproduces same when connected externally.

CELL, VOLTAIC.—The combination of two metals which when dipped into an electrolyte and connected outside the liquid by a conductor will produce a current of electricity.

CENTRIFUGAL FORCE.—Force caused by a body tending to fly off at a tangent when revolving in a circle.

CHANGE-GEARS.—The gear wheels which are used to change the revolutions of a feed or lead screw.

CHASER.—A tool for cutting threads in a lathe by hand.

CHECK-NUT.—An additional nut screwed against the first to check the tendency to work back.

CHISEL-TOOTH SAW.—A saw with inserted teeth having a heavy front rake.

CHUCK.—A tool to hold work in a lathe or device to hold another tool, as a drill-chuck.

CHUCK-PLATE.—A face plate constructed so that work can be chucked on it.

CIRCUIT, CONSTANT POTENTIAL.—A circuit the potential of which remains constant.

CIRCUIT, EARTH.—A circuit in which the ground forms the return path.

CIRCUIT, METALLIC.—A circuit in which metallic conductors are alone employed, and ground is not used for return.

CIRCUIT, MULTIPLE, Multiple-arc-parallel or Quantity. —Two or more generators or receptive devices having their positive poles connected to one conductor and all their negative poles connected to a second conductor.

CIRCUIT, MULTIPLE-SERIES.—Two or more groups of electrical apparatus connected in multiple, the separate parts of each group being connected in series.

CIRCUIT SERIES.—A compound circuit. as a chain, in which the sources, or receptive devices form links and are so arranged that the current must pass successively through from the first to the last.

CIRCUIT, SHUNT.—A branch, by-path or second circuit of comparatively high resistance through which a portion of the circuit flows.

CIRCULATING PUMP.—The pump employed to drive the cooling water through a condenser.

CLEARANCE.—The volume included between the piston and the valve seat when the piston is at the end of its stroke.

CLEMENTS-DRIVER.—A device for driving workk in a lathe, which equalizes the strain on the two ends of the carrier or dog.

CLUTCH.—An engaging and disengaging device which enables motion to be communicated from one part to another, or the same to be stopped.

COG.—A wooden tooth for a gear wheel.

COIL, CHOKING OR IMPEDENCE.—A coil of iron so wound on a core of iron as to possess high self-induction.

COIL, INDUCTION, RHUMKORFF.—Two parallel coils of insulated wire employed for the production of currents by mutual induction.

COIL, PRIMARY.—The coil or conductor of an induction coil or transformer through which the rapidly interrupted ar alternating primary or inducing current is sent.

COIL, SECONDARY.—That coil of an induction coil or transformer in which currents are induced by alternations or interruptions of the current passed through the primary coil.

COILS. ARMATURE. OF DYNAMO-ELECTRIC MACHINE.—The conductor wound or placed on the armature.

COLD, PRODUCTION OF, BY ELECTRIGITY.—When an electric current passes across a thermo-electric junction, the junction is either heated or cooled, according to the direction of the current.

COLLAPSING-TAP.—A tap so formed that its teeth close inwards when the thread is cut. permitting the tap to be withdrawn without winding it backward.

COMBINATION-CHUCK.—A chuck so constructed that the jaws may be moved either simultaneously or individually.

COMMUTATOR, DYNAMO-ELECTRIC MACHINE.—That part of a dynamo-electric machine which is designed to cause the alternating currents produced in the armature to flow in one and the same direction in the external circuit.

COMPOUND-GEARS.—A train of gear wheels in which two wheels of different diameters are fixed on one shaft so that the velocity may be varied.

COMPOUND SLIDE-REST.—A slide-rest with two slides. one above the other.

COMPRESSION. — The pressure caused at the end of stroke by closing the exhaust port.

COMPRESSION LINE.—The line traced on an indicator card from the time the exhaust port is closed to the beginning of the stroke.

CONDENSATION, INITIAL.—The condensation which takes place when steam enters the cylinder at the beginning of each stroke.

CONDENSER.—1. Cooling apparatus for condensing exhaust steam. 2. (Leyden jar). Device for increasing the capacity of an insulated conductor; and induction device.

CONDENSER, CAPACITY OF,—The quantity of electricity in coulombs a condenser is capable of holding before its potential in volts is raised to a given amount.

CONDENSER, SURFACE. — One in which the steam comes in contact with surfaces cooled by air or water.

CONE-BEARING.—A journal bearing which has a second sleeve that may be moved endwise to take up wear.

CONE-MANDREL.—A mandrel which employs two cones to hold hollow work.

CONE-PLATE.—A device with a coned mouth which supports one end of work in a lathe. thereby steadying it.

CONTACT-BREAKER, AUTOMATIC. — A device for causing an electric current to rapidly make and break its own circuit.

CONTROLLER.—An automatic magnetic regulator for a dynamotelectric machine.

CONVERSION, EFFICIENCY OF, OF DYNAMO.—The total electricity energy develop by a dynamo, divided by the total mechanical energy required to drive the dynamo.

CONVERTER.—The inverted transformer or induction coil used on alternating current systems.

CORE, ARMATURE OF DYNAMO-ELECTRIC MACHINE.—Iron core on or around which the armature coils of a dynamo-electric machine are wound or placed.

CORE, ARMATURE, LAMINATION OF. — A subdivided core in separate insulated plates or strips for the purpose of avoiding eddy currents.

CORE, ARMATURE, VENTILATION OF.—Means for passing air through the armature core of a dynamo-electric machine in order to reduce the heating.

CORE. LAMINATIONS OF.—Structural subdivisions of the cores of magnets.

CORE, SOLENOID.—A core so arranged as to be drawn into a solenoid on the passage of the current through the coils.

COULOMB.—The unit of electrical quantity. That quantity of electricity which would pass in one second through a resistance of one ohm with a pressure of one volt.

COUNTER-SHAFT.—A small shaft with pulleys upon it, one usually being an idler. to permit a machine to be started and stopped without stopping the main shaft or driving belt, and also to vary the speed of the machine.

COUNTERSINK.—A tool for cutting an enlargement, cone-shaped or perpendicular, at the mouth of a hole.

COUPLE, ASTATIC.—Two magnets of equal strength suspended one over the other in the same vertical plane so as to completely neutralize each other.

COUPLE, THERMO-ELECTRIC,—Two dissimilar metals which, when connected at their ends only so as to form a complete circuit and one of the ends is heated. will produce an electric current.

COUPLE, VOLTAIC, GALVANIC,—Two dissimilar metals in an electrolyte and capable of producing an electric current.

C. P.—Contraction for candle power.

CRANK.—Arm which turns the engine shaft of an engine.

CRANK-PIN.—The pin in end of the crank to which the connecting rod is attached.

CROSSING, LIVE TROLLEY.—A device whereby a trolley moving over a line that crosses a second line at an angle is enabled to maintain its electrical connection with the line while crossing.

CROWK-WHEEL.—A gear wheel whose teeth are on its side face.

CURRENT DENSITY.—The current which passes in any part of a circuit as compared with the area of cross-section of that part of the circuit.

CURRENT, ELECTRIC.—The quantity of electricity which passes per second through any conductor or circuit.

CURRENT, GENERATION OF BY DYNAMO-ELECTRIC MACHINE.—The difference of potential developed in the armature coil by the cutting of the lines of magnetic force of the field by the coils during the rotation of the armature.

CURRENT, INDUCED.—The current produced in a conductor by cutting lines of force.

CURRENT, ROTATING.—Term applied to a current which results by combining a number of alternating currents whose places are displaced with respect to one another.

CURRENT STRENGTH.—The product obtained by dividing the electro-motive force by the resistance. According to ohm's law. the strength for a constant current is:

$$C \text{ (current)} = \frac{E \text{ (electromotive force)}}{R \text{ (resistance)}}$$

CURRENT, TRANSFORMING A.—Changing the electromotive force of a current by its passage through a converter or transformer.

CURRENT UNIT, STRENGTH OF.—Such a strength of current that when passed through a circuit one centimeter in length, arranged in an arc one centimeter in radius, will exert a force of one dyne on a unit magnet pole placed at the center, equal to ten amperes.

CURRENTS, EDDY.—Useless currents produced in the pole pieces. armatures and field-magnet cores of dynamo electric machines or motors.

CURRENTS, SIMPLE PERIODIC.—Alternating currents. A current of such a nature that the continuous variation of the flow past any cross section of the conductor, or the variation in the electro-motive force of which can be expressed by a simple, periodic curve.

CURRENTS, UNDULATORY.—Currents, the strength and direction of whose flow gradually changes.

CURVE, CHARACTERISTIC.—A diagram in which a curve is employed to represent the ratio of certain varying values.

CUSHIONING.—The closing of the exhaust port before the end of the stroke to allow the steam thus enclosed to take up the shock of reciprocating parts.

CUT-OFF.—The point of stroke at which the steam port is closed.

CUT-OUT.—A device that will remove an electro-receptive device from the circuit.

CUT-OUT, TO.—To remove an electro-receptive device from the circuit of an electric source by disconnecting or diverting the circuit from it.

CYCLOID.—A curve generated by a pencil fixed in the perimeter of a circle when rolled upon another circle.

CYCLE, MAGNETIC.—Single round of magnetic charges to which a magnetizable substance is subjected when it is magnetized from zero to a certain maximum and then decreased to zero and so on.

D

DAMPER.—A retarding device: A metallic device surrounding the core of an induction coil for the purpose of varying the intensity of the induced currents.

DAMPER, ARC-LAMP.—The dash-pot or other device offering resistance to quick motion.

DEAD-BEAT.—A swinging magnetic needle which is quickly brought to rest. Such a motion of a galvanometer needle in which the needle moves sharply over the scale from point to point and comes quickly to rest.

DEAD-POINT or DEAD-CENTER.—Position of crank-pin when piston rod, connecting rod, and crank are in a straight line.

DECLINATION, ANGLE OF.—The angle which measures the deviation of the magnetic needle from the true geographical north.

DEKA (AS A PREFIX).—Ten times, as deka-ampere.

DEMAGNETIZATION.—A process by which a magnet is deprived of its magnetism.

DENSITY. ELECTRIC.—The quantity of free electricity an any unit of area or furface.

DEPOLARIZATION.—Depriving a voltaic cell of its polarization.

DEPOSIT, ELECTRO-METALLURGICAL.—The deposit of metal by the process of electro-metallurgy.

DETECTOR, GROUND.—A device in an incandescent lamp-system for showing the location of a ground.

DEVICE, ELECTRO-RECEPTIVE.—Any device placed in an electric circuit and energized by the current, such as motors, telegraphs and telephones, lamps, transformers, etc.

DIAMAGNETIC.—The reverse to magnetic attraction; metals, etc., which are repelled by the poles of magnets are called diamagnetic.

DIAPHRAGM.—A plate or sheet securely fixed at its edges, as a drum head, and capable of being set in vibration, as a telephone diaphragm.

DIELECTRIC.—A substance which permits induction to take place through its mass.

DIMMER.—A choking coil employed on transformer circuits to regulate the potential.

DIP, MAGNETIC.—Deviation of a magnetic needle from a true horizontal position. Its inclination towards the earth.

DISC, ARAGO'S.—A non-magnetic metal disc, as of copper, which, when rapidly rotated under a freely supported magnetic needle, will cause the needle to be deflected or to rotate.

DISC, FARADAY'S.—A non-magnetic metal disc fixed on an axis parallel to the direction of the magnetic field in which it is to move.

DISCHARGE.—To equalize the potential. The equalization of the difference of potential by metalically connecting the terminals.

DISCHARGE, BRUSH.—A faintly luminous discharge that occurs from a pointed positive conductor.

DISCHARGE, OSCILLATING.—Successive discharges and recharges which occur on the disruptive discharge of a condenser.

DISCHARGE, VELOCITY OF.—The time required for the passage of a discharge through a given length of conductor.

DISTRIBUTION, CENTER OF.—In electrical engineering, any place in a system of multiple-distribution where branch cut-outs and switches are located.

DOG.—A device for holding or steadying work.

DOG-HEAD.—A hammer for straightening saw or other plates.

DOME.—The upright cylindrical drum attached directly to a boiler; used as a steam-chamber.

DOUBLE-DECK BOILER.—One composed of two cylindrical shells placed vertically above each other.

DRIFT-PIN.—The punch-like tool driven into rivet holes when the holes of two plates do not coincide.

DROP-HAMMER.—A hammer for forging, stamping or other work, which is raised by power and falls by gravity.

DRUM.—A cylindrical chamber connected in some way to the main boiler.

DOUBLE SLIDE-REST.—A feed motion in which there are two slide-rests on one slide-way.

DUTY.—The amount of work done by an engine as compared with the work or fuel consumed.

DYNAMO, INDUCTOR.—A dynamo machine for alternating currents in which the difference of potential causing the currents is obtained by magnetic changes in the cores of the armature and field coils by the movement past them of laminated masses of iron inductors.

DYNAMO, POLYPHASE.—A dynamo from which two or more alternating currents are taken.

DYNAMO, ROTARY-PHASE.—Rotating current dynamo.

DYNAMO, SEPARATELY-EXCITED.—Dynamo whose fields are separately excited.

DYNAMOMETER.—Instrument for measuring power.

DYNAMOMETER, ELECTRO.—A form of galvanometer for the measuring of electric currents.

DYNE.—The unit of force. The force which, in one second, can impart a velocity of one centimetre per second to a mass of one gramme.

E

EARTH OR GROUND.—A plate buried in the ground to make connection between line aud earth where the earth is used as the return circuit. A fault in a line caused by its contact with the earth. That part of the earth which forms part of an electric circuit.

ECCENTRIC.—A disk placed off the center on a shaft.

ECCENTRIC, THROW OFF.—Amount of offset given an eccentric.

EFFECT, FERRANTI.—A difference of potential of mains towards their ends furthest from the terminals connected with a source of constant potential.

EFFECT, HALL.—The Hall effect is produced by placing a thin, metallic strip, conveying an electric current, in a strong, magnetic field. A transverse electromotive force, produced by a magnetic field in substances undergoing electric displacement.

EFFECT, JOULE.—The beating effect produced by the passage of an electric current through a conductor.

EFFECT. THERMO-ELECTRIC.—The production of an electromotive force at a thermo-electric junction by a difference of temperature.

EFFECT, THOMSON.—The production of an electromotive force in unequally heated homogeneous conducting substances.

EFFECT, VOLTAIC.—A difference of potential at the point of contact of the two dissimilar metals.

EFFICIENCY, BOILER.—Ratio of total amount of heat in the steam given out by a boiler to the total heat given out by the fuel.

EFFICIENCY, COMMERCIAL OF DYNAMO.—The available electrical energy in the external circuit. divided by the total mechanical energy required to drive the dynamo that produced it.

EFFICIENCY, ELECTRIC.—The useful electrical energy of any source, divided by the total electrical energy.

EFFICIENCY, ENGINE.—Ratio of amount of energy given out by an engine in the form of work to total amount of energy given to the engine in the form of heat in the steam.

EFFICIENCY, QUANTITY, OF STORAGE BATTERY. The ratio of the number of ampere-hours taken out of a secondary battery, to the number of ampere hours put in the battery in charging it.

EFFICIENCY, REAL, OF STORAGE BATTERY.—The ratio of the number of watt-hours taken out of a storage battery, to the number of watt-hours put into the battery in charging it.

ELECTRICITY, DISTRIBUTION OF, BY ALTERNATING CURRENTS.—A system of electric distribution by the use of alternating currents, transformed before passing through lamps, motors, etc.

ELECTRICITY, DISTRIBUTION OF, BY CONSTANT CURRENTS.—A system for the distribution of electricity by means of direct i. e. continuous, steady or non-alternating currents.

ELECTRICITY, DISTRIBUTION OF, BY CONTINUOUS CURRENTS, BY MEANS OF TRANSFORMERS.—A system for the transmission of electric energy by means of direct currents that are sent over the line to stations where motor-dynamos are used for transformers.

ELECTRICITY, MAGNETO.—Electricity produced by the motion of magnets past conductors, or of conductors past magnets.

ELECTRICITY, NEGATIVE.—The kind of electric charge produced on rosin when rubbed with cotton. The opposite to positive electricity.

ELECTRICITY, POSITIVE.—The kind of electric charge produced on cotton when rubbed against rosin.

ELECTRICITY, STATIC.—A term applied to electricity produced by friction.

ELECTRICITY, THERMO.—Electricity produced by difference of temperature of dissimilar metals.

ELECTRICITY, UNIT OF QUANTITY.—The current of electricity conveyed by unit current per second. The coulomb which is the quantity conveyed by a current of one ampere in one second.

ELECTRODE.—The terminals of an electric source.

ELECTRODES, CARBON, FOR ARC LAMPS.—Rods of artificial carbon employed in arc lamps.

ELECTROLYSIS.—Chemical decomposition effected by means of an electric current.

ELECTROLYTE, POLARIZATION OF.—When the poles of all the molecules of any chain are turned in the same direction, viz: with their positive poles facing the negative plate, and the negative poles facing the positive plate.

ELECTROMETER, QUADRANT.—An electrometer in which an electrostatic charge is measured by the attractive and repulsive force of four plates or quadrants, on a light needle suspended within them.

ELECTROSCOPE.—An apparatus for indicating the presence of an electric charge and determining whether the charge is positive or negative.

ELECTROSCOPE, GOLD-LEAF.—An electroscope employing two leaves of gold to detect the presence and polarity of a charge.

ELECTROSTATICS.—That which treats of the phenomena and measurement of electric charges.

ELECTROTYPE.—An impression consisting of a thin shell, or coating of metal, usually copper, deposited on a plate by means of electro metallurgy, being afterwards backed by soft metal.

ELEMENT.—Matter that is composed of but one kind of atoms and cannot be decomposed into simpler matter.

ENERGIZING, ELECTRICALLY.—An effect caused by electricity in an electro-receptive device, as energizing an electro-magnet by passing current through the coils.

ENERGY, ELECTRIC.—The power which electricity posseses of doing work. The current in amperes, multiplied by the differential of potential in volts, divided by

746, equals the rate of doing work in horse-power. 746 volt amperes, or watts, equals one horse-power.

ENERGY, ELECTRIC, TRANSMISSION OF.—The transmission of mechanical energy between two distant points connected by an electric conductor, by converting the mechanical energy into electrical energy at one point, sending the current so produced through the conductor, and reconverting the electrical into mechanical energy at the other point.

ENERGY, POTENTIAL OR STATIC.—Energy possessing the power of doing work. but not actually performing such work. Stored énergy, or the power of doing work by a body at rest.

ENGINE, BLAST.—One used to force a blast of air, as for a blast furnace.

ENGINE, COMPOUND.—One in which the same steam is used in two or more cylinders.

ENGINE, CONDENSING.—One in which the exhaust steam. is condensed back into water.

ENGINE, DOUBLE, TRIPLE, QUADRUPLE, EXPANSION. One in which the same steam is used in 2, 3 and 4 cylinders respectively.

EQUATOR, MAGNETIC. — An irregular line passing through the earth approximately midway between the earth's magnetic poles.

EQUIVALENCE, CHEMICAL. —The quotient obtained by dividing the atomic weight of any elementary substance by its atomicity. That quantity of an elementary substance that is capable of combining with or replacing one atom of hydrogen.

EQUIVALENCE, ELECTRO-CHEMICAL.—The chemical equivalent of a substance multiplied by the electrochemical equivalent of hydrogen.

EQUIVALENCE, ELECTRO-CHEMICAL, LOSS OF. —The amount of chemical action produced by an electric current, passed through various chemical substances, is proportional to the chemical equivalent of each substance.

ERG.—The work done when a body is moved through a distance of one centimeter with the force of one dyne. A dyne centimeter.

EVAPORATION, ELECTRIC.—The formation of vapors at the surface of substances by the influence of negative electrification.

EXPANDING CHUCK.—A chuck that usually holds work from its bore and is capable of expanding to adjust itself to a difference in diameter of a piece of work.

EXPANDING-MANDREL.—Mandrel whose diameter may be varied, generally constructed with adjustable jaws.

EXPANSION-JOINT.—A joint placed in a pipe to allow the same to expand and contract under changes in temperature.

EXPLODER, ELECTRIC MINE OR ELECTRO-MAGNETIC.—A magneto-electric machine used to produce the currents of high electro-motive force employed in the direct firing of blasts.

EXTENSION LATHE.—A lathe with a bed in two longitudinal parts so that the upper one supporting the carriage may be moved from the face-plate, leaving a gap and permitting work of larger diameter to be chucked.

F

FACE-CAM.—A cam whose actuating surface is on its side or sides.

FARAD.—The practical unit of electric capacity.

FEATHERING PADDLE WHEEL.—One in which the floats are raised out of the water edgewise.

FEED, CHECK-VALVE.—The valve placed in the feed pipe of a boiler to prevent water from leaking back through the pump or injector.

FEED, CLOCKWORK FOR ARC LAMPS.—An automatically started arrangement of clockwork for obtaining a uniform feed motion of one or both electrodes of an arc lamp.

FEED-MOTOR.—The part of a machine which feeds either the tool or the work, so that a cut may be made.

FEED-WATER HEATER.—A sort of boiler generally heated by exhaust steam through which feed water for a boiler is passed for the purpose of heating it.

FENCE.—A plate in a machine to hold work in position.

FIDDLE-DRILL.—A drill that is revolved back and forth by means of a bow with a string to it.

FIELD, AIR.—That portion of a magnetic field in which the lines of force pass through air only.

FIELD, ALTERNATING, MAGNETIC.—A magnetic field the direction of whose lines of force is alternately reversed.

FIELD, ELECTRO-MAGNETIC.—The space traversed by the magnetic force produced by an electro-magnet.

FIELD, ELECTROSTATIC.—The region of electrostatic influence surrounding a charged body.

FIELD, MAGNETIC.—The region of magnetic influence surrounding the poles of a magnet.

FIELD, MAGNETIC, ALTERNATING.—The magnetic field produced by an alternating current.

FIELD, MAGNETIC, REVERSING. — That portion of the field of a dynamo-electric machine, produced by the field-magnet coils, in which the currents flowing in the armature coils are stopped or reversed after the coil has passed its theoretical position of neutrality.

FIFTH-WHEEL.—The circular slideway which permits the front axle of a vehicle to be turned horizontally.

FILLISTER-HEAD.—A cylindrical serew-head that contains a screw-slot.

FINDER-WIRE.—Galvanometer used to locate the correponding ends of different wires in a bunched cable.

FIRE-BOX.—The chamber or box containing the fire in all boilers in which the same is surrounded by water.

FIT-STRIP.—A projection about an inch in width for the purpose of being fitted to bed a piece properly, to obviate bedding the entire surface of the piece.

FLAT-CHISEL.—A machinist's chisel, wedge-shaped.

FLAT-DRILL.—A drill of rectangular cross-section.

FLATTER.—A swage for plane or flat surfaces.

FLEXIBLE-SHAFT.—A wire shaft constructed similar to wire rope, for transmitting rotary motion. It may be bent and still perform its office.

FLUX or FLOW, MAGNETIC.—The total number of magnetic force in any magnetic field.

FLY-WHEEL.—The wheel with a heavy rim placed on an engine shaft to give a steady motion to the engine.

FOLLOW-BOARD.—A piece constructed to fit a pattern, to prevent the latter from warping.

FOLLOW-REST.—A rest which steadies work on a lathe and travels with the carriage.

FOOT-BLOCK.—A work-holding device with a dead center, for use on a milling machine.

FOOT-POUND.—The unit of work. The amount of work required to raise a pound vertically through a distance of one foot.

FORCE, CENTRIFUGAL.—Force that is supposed to urge a rotating body directly away from the center of rotation.

FORCE, CONTACT.—A difference of electrostatic potential produced by the contact of dissimilar metals.

FORCE, ELECTROMOTIVE. ABSOLUTE UNIT OF.—A unit of electromotive force, expressed in absolute or C. G. S. units. The one-hundred millionth part of a volt.

FORCE, ELECTROMOTIVE, COUNTER OR BACK.—A reverse electromotive force, which tends to cause a current in the opposite direction to that actually produced by the source.

FORCE, ELECTROMOTIVE, COUNTER OF MUTUAL INDUCTION.—The counter electromotive force produced in the primary circuit of an induction coil by the action thereon of a simple-periodic e. m. f.

FORCE, ELECTROMOTIVE, DIRECT.—An e. m. f. acting in the same direction as another e. m. f. already existing.

FORCE, ELECTROMOTIVE, IMPRESSED.—The e. m. f. acting on any circuit to produce a current therein.

FORCE, ELECTROMOTIVE, SIMPLE PERIODIC.—An e. m. f. which varies in such manner as to produce a simple-periodic current, or an e. m. f., the variations of which are correctly represented by a simple-periodic curve.

FORCE, ELECTROSTATIC, LINES OF.—Lines extending in the direction in which the force of electrostatic attraction or repulsion acts.

FORCE, MAGNETO-MOTIVE.—That difference of magnetic potential or magnetic pressure existing in a magnetic circuit which creates the magnetic lines of force.

FORCE, MAGNETO-MOTIVE, PRACTICAL UNIT OF.—A value of the magneto-motive force equal to $\frac{4\Pi}{10} = 1.25564$ times the amperes of one turn. (The Greek letter pi is used in engineering as the symbol for ratio of circumference to diameter, i. e., 3.1416; the diameter multiplied by Π equals circumference.

FORCED-DRAUGHT.—Forcing of air through a furnace by means other than the natural draught of a chimney.

FORK, TROLLEY.—The mechanism connecting the trolley-wheel mechanism to the trolley pole.

FORMER.—A piece that guides or controls the movement of a cutting tool; also a template to which pieces are shaped.

FRICTION-GEARING. — Wheels which transmit motion by frictional contact on their circumference.

FROG, TROLLEY. — A device employed in fastening together trolley wires where they branch off, and as a guide to the trolley wheel.

FURNACE, ELECTRIC.—An electrically heated furnace, employed for the purpose of effecting difficult fusion.

FUSIBLE-PLUG,—Plugs of metal placed in holes in the parts of a boiler exposed to the highest heat which would melt before the plates could be injured by heat.

G

GALVANIC ACTION OR VOLTAIC ACTION. — Corroding of plates and stays supposed to be caused by electric currents being generated by the impurities in water acting on the plates, especially where copper is used.

GALVANOMETER. — An apparatus for measuring the strength of an electric current.

GALVANOMETER, ASTATIC.—One having two needles so arranged that the earth's magnetism has little or no effect on them.

GALVANOMETER, BALLISTIC.—A galvanometer designed to measure the strength of a current that lasts but for a moment, such, for example. as the current caused by the discharge of a condenser.

GALVANOMETER, DIFFERENTIAL.—A galvanometer containing two coils so wound as to tend to deflect the needle in opposite directions.

GALVANOMETER, MARINE.—A galvanometer for use on steam ships where the motion of magnetized masses of iron would seriously disturb the needles of ordinary instruments.

GALVANOMETER, MIRROR OR REFLECTING.—A galvanomejer in which instead of reading the deflections of the needle directly by its movement, over a graduated scale, thep are read by the movement of a spot of light reflected from a mirror attached to the needle.

GALVANOMETER, VOLTMETER.—An instrument for the measuring of differences of electrical potential.

GANG-MILLS.— Milling machine cutters placed side by side on the gangs.

GAP, AIR.—An opening or gap in a magnetic circuit containing air ohly.

GAP-LATHE.—A lathe having a gap in its bed to permit work to be chucked which would not otherwise clear the guides.

GAUGE-COCK.—A stop cock placed at different levels on a boiler; the level of the water being determined by the issuing of steam or water from it.

GAUGE, WIRE, MICROMETER.—A micrometer gauge employed for measuring the diameter of a wire in thousandths of an inch.

GAUGES, WIRE, VARIETIES OF.—The principal wire gauges in use are given in the following table: There are three standards as follows: Brown & Sharp. or American; Birmingham or Stub's; English Legal Standard. An idea of the gauges compared, can be had from the following (the diameter of the wire is given in mills):

Gauges.	No. 0 Wire.	No. 10 Wire.	No. 30 Wire.
B. & S.	324.86	101.89	10.925
Birmingham................	340.	134.	12.
English Standard..........	324.	128.	12.4

GEAR-WHEEL.—A wheel provided with teeth for engaging with those of a similar wheel.

GENERATOR, DYNAMO-ELECTRIC.—A machine in which electricity is produced by the movement of conductors through a magnetic field in such a manner as to cut the lines of force. A Dynamo-electric machine.

GOOSE-NECK.—A frame constituting a fulcrum for a rachet brace.

GOVERNOR.—A device for maintaining constant the speed of a steam engine or other prime mover, despite sudden changes in load.

GOVERNOR, CENTRIFUGAL.—One which depends for its action upon the change in the centrifugal force exerted upon certain of its parts due to change of speed.

GOVERNOR, FLY-WHEEL OR SHAFT.—One used on automatic engines and contained in the fly or belt wheel and connected to the eccentric.

GRAMME.—A unit of weight in the metric system, equal to 15,43235 grains. Also written Gram.

GRAVIS.—A hand tool of rectangular cross section having cutting edges at its end, which are formed by grinding the end face at an acute angle to the body of the tool.

GRID.—A lead plate, provided with perforations employed in storage cells for the support of the active material.

GROUND.—Contact of an electric conductor with the earth.

GROUND RETURN.—A term applied when the earth is used as part of an electric circuit.

GUIDE-BAR.—A bar on which slides a moving or reciprocating part, as an engine's cross-head.

GUM.—The bottom section between saw teeth.

GUSSET-STAYS.—Triangular shaped stays made of boiler plate used for such places as staying the end of a boiler to the side.

H

HALF-CHECK JOINT.—A joint in which a piece is let into another so that the surface comes level.

HAMMER-TEST.—Test of a boiler made by hammering the plates, defects being located by the sound.

HAND-HOLE.—The holes placed in the sides of a boiler large enough to admit the hand for cleaning, etc.

HEAD-END.—End of the cylinder away from the crank.

HEAT OF EVAPORATION.—Amount of heat necessary at a given pressure to turn a unit of water into dry steam.

HEAT, MECHANICAL EQUIVALENT OF. — The amount of mechanical energy converted into heat. The mchanical equivalent of one unit of heat is equal to 772 foot pounds of work.

HEAT, SPECIFIC.—The capacity of a body for heat compared with that of an equal quantity of some other substance, usually water.

HEAT UNIT (BRITISH).—The quantity of heat required to raised the temperature of a pound of water from 32 to 33 degrees Fahrenheit.

HEATING-SURFACE.—The surface plates of a steam boiler which receive the flame or heat on one side and which have water on the reverse side.

HINDLEY'S SCREW.—Short length of screw, sometimes called an endless screw, used to drive a worm wheel.

HORSE POWER (H. P.).—A commercial unit for power or rate of doing work. A rate of doing work equal to raising 550 pounds one foot in one second. or 33,000 pounds one foot in one minute, and always involveing the three factors, force, distance and time.

HOUR LAMP.—A service of electric current which will maintain one electric lamp one hour.

HOUR, WATT.—An expenditure of one watt for one hour. A unit of electrical work.

HUNTING-TOOTH.—An extra tooth placed in a pair of gear wheels to vary the number of teeth. so that the same teeth will not always engage together.

HYPOCYCLOID.—A cycloidal curve in which the rolling circle is rolled within the buse (or fixed) circle.

I

IMPEDANCE.—The sum of all resistance, ohmic and spurious. in a circuit, expressed in ohms.

INCLINATION, ANGLE OF.—The angle of magnetic dip. The angle which a magnetic needle, free to move in a vertical and horizontal plane, makes with a horizontal line passing through its point of support.

INDEX-PLATE.—A circular disk divided (generally by holes bored in its face) so that a complete circumference or 360° may by equally divided into any number of parts, within the limits of the plate.

INDICATOR—An instrument for recording the pressure in a cylinder at each point of the stroke.

INDICATOR, SPEED.—A device for indicating the revolutions per minute of a shaft or machinery. A tachometer.

INDUCTION.—The influence which a charged body or magnetic field exerts on bodies near but not in contact with it.

INDUCTION, ELECTROSTATIC.—The charge produced when a conductor enters an electrostatic field.

INDUCTION, MAGNETIC.—The magnetization in a magnetic field of any magnetizable substance.

INDUCTION, SELF, CO-EFFICIENT OF.—The quantity of induction passing through a circuit per unit current in the circuit.

INSULATION OR INSULATOR.—A non-conductor of electric current, used to prevent leakage of current.

INTENSITY, PHOTOMETRIC, UNIT OF.—The light produced by the consumption in a wax candle of two grains of spermaceti wax per minute.

INVOLUTE.—Curve formed by the path of a given point in a straight line when the line is rolled upon a circle.

IONS.—The products of decomposition in any given electrolysis ; those adhering to the positive are Kathion and to the negative Anion.

IRON-WORK FAULT OF DYNAMO. — The short-circuiting of a dynamo by improper contact between its coils and any iron.

ISOCHRONISM.—Equality of the periods of vibration.

ISOTHERMAL EXPANSION. — Expansion of a gas where its temperature is kept constant by supplying heat externally.

J

JACKET.—An annular space around a cylinder.

JAR, LEYDEN.—A static condenser in the form of a jar. The coatings of metal are placed on the lower exterior and interior walls, about two-thirds the depth of the jar, the rest being varnished or shellacked. It has a cork cover through which a brass rod extends making contact with its interior. The rod has a ball on top.

JOINTS OF BELTS, BUTT AND LAP.—The butt joint in a belt is one in which the two ends are cut square, brought together so that they abutt directly and laced. In the lap joint the ends are overlapped and laced or riveted through.

JOULE.—The practical C. G. S. unit of electrical energy or work. One joule = 10,000,000 ergs. One joule per second = 1 watt.

JOURNAL.—The part of a shaft that runs in a bearing or journal box.

K

KATHODE OR CATHODE.—The terminal connected to the negative or carbon plate of an electrolytic cell.

KEY, DISCHARGE AND CHARGE.—A key by the use of which the discharge from a condenser is passed through a galvanometer for measurement.

KILODYNE.—One thousand dynes.

KILOGRAMME.—One thousand grammes. About 2 1-5 pounds avoirdupois.

KINETICS, ELECTRO.—Electric currrents, or electricity in motion, in contradistinction with electrostatics, or electricity at rest.

KNURLING OR MILLING TOOL.—A tool to form indentations or corrugations upon the surfaces of metal parts so that the hand may grip the part more securely.

L

LAG, ANGLE OF.—The angle describing the shifting of the magnetic axis of the armature core of a dynamo, caused by the resistance of the core to the sudden reversals of magnetism.

LAG, MAGNETIC.—The viscosity of iron or steel, which renders it slow to take up and part with magnetism. This sluggishness is one of the causes necessitating "lead" of the brushes.

LAMP, INCANDESCENT, STRAIGHT-FILAMENT.—Lamp with a straight filament, rendered luminous by high frequency electrostatic waves. It is the invention of Tesla.

LAMP, INCANDESCENT, THREE-FILAMENT.—An incandescent lamp provided withe three filaments and three leading-in wires connected thereto. It is used on three-phase circuits.

LANTERN.—A form of gear of early practice in which rungs are employed in place of teeth.

LAP.—Projection of the valve beyond the ports when in mid-position.

LATENT HEAT.—Heat which is used up in changing the molecular condition of a body without changing its temperature, as in changing ice at 32 degrees to water at 32 degrees, and water at 212 degrees to steam at 212 degrees Fahrenheit.

LAW OF JACOBI.—The work of an electric motor is at its maximum when the counter e. m. f. is equal to half the e. m. f. expended on the motor, or the impressed e. m. f.

LAW OF JOULE.—A current heating power is proportional to the product of the square of the current strength and the resistance.

LAW OF OHM.—The fundamental law of the relations between current, e. m. f. and resistance in an electric circuit, or the law of current strength. The strength of a continuous current is directly proportional to the e. m. f. in the circuit, and inversely proportion to the resistance in it, or the e. m. f. divided by the resistance, The algebraic expression for Ohm's law is

$C \text{ (current)} = \dfrac{E \text{ (electromotive force)}}{R \text{ (resistance)}}$. To get E. in terms of the other two factors, we have: $E = C\,R$, or $C \times R$; and for a similar expression for R, we have, $R = \dfrac{E}{C}$.

LAW OF VOLTA.—A law for the e. m. f. between dissimilar metals in an electro chemical series. It is: "The difference of potential between any two metals is equal to the sum of the differences of potential between the intervening substances in the contact series."

LAWS OF COULOMB, OF ELECTROSTATIC ATTRACTION AND REPULSION.— 1. The attractions and repulsions between two bodies electrified are in inverse ratio of the square of their distance. 2. The force of attraction or repulsion between two electrified bodies is directly as the product of the quantities of electricity they are charged with, the distance remaining the same.

LAWS OF FARADAY.—Laws expressing the effects of electrolysis.

LAWS OF JOULE.—Laws for the development of heat in electric circuits.

LAWS, LENZ'S.—The rules for determining the directions of currents produced by electro-dynamic induction formulated by Lenz.

LEG.—A wire used on a telephone switchboard for placing one subscriber in circuit with two or more telephones.

LIGHTING, ELECTRIC, BY HIGH FREQUENCY.—A system invented by Tesla, in which rods of carbon or other refractory substances are placed in an electrostatic field rapidly alternating, and raised to incandescence.

LINE-SHAFT.—Shaft that receives motion directly from an engine or other motor, and transmits it to various points.

LINES, KAPP.—Proposed as a unit for lines of magnetic force, 1 Kapp line to equal 6,000 C. G. S. units.

LINES, VORTEX-STREAM.—Lines whick extend in the direction of the motion of the particles of a fluid.

LINK.—The curved slotted piece to which the two eccentric rods are attached on a reversing engine.

LIQUID, ELECTROPOION. — A liquid for a battery, composed as follows: 2½ pounds of sulphuric acid are placed in 10 pounds of water, in which 1 pound of bicromate of potash is dissolved.

LOAD, LIQUID.—Resistance. or load, made by placing the terminals of a dynamo in water, which completes the circuit.

LOG, ELECTRIC.—An electric indicator for measuring the speed of a ship.

LOOP, DRIP.—A pendant or downward loop formed in electric wires immediately before entering a building to prevent the passage of water on the wire into the building.

LUBRICATOR.—A cup arranged to feed oil to rubbing surfaces and into the steam which is being supplied to an engine.

M

MACHINE, DYNAMO-ELECTRIC.—Device or machine by means of which mechanical power is transformed into electric by magneto electric induction, or by which electric is converted into mechanical power. the latter being called a motor. Such a machine consists, first, of a circuit of iron, made up of frame, pole pieces and an armature core which rotates between the pole pieces as close to their faces as practicable; second, coils of copper wire around the iron poles, which, when energized by an electric current, make electromagnets or fields of the poles and cause a magnetic circuit to flow through the poles and armature core; third, coils of copper wire wound around the armature core, which, on being rotated, cut the magnetic lines of force and develop electromotive force; fourth, a collecting device connected with the armature, called a commutator in direct current machines; fifth, brushes of copper or carbon resting on this collecting cylinder which carry off the current generated.

MACHINE, DYNAMO, ALTERNATING CURRENT.—A dynamo which produces alternating currents for work. It is an ordinary dynamo the currents from which are not commuted or made to flow in one direction by means of a commutator. The field are usually separately excited, as a direct current is required for their excitation.

MACHINE, DYNAMO, OUTPUT OF.—The current generated in and put out by a dynamo, measured in watts, or kilowatts.

MACHINE, DYNAMO, SEPARATELY-EXCITED.—A dynamo whose field coils receive current for their excitation from some source other than its own armature. They are usually alternating current dynamos.

MACHINE, DYNAMO, SHUNT.—A dynamo in which part of the current goes through the fields to excite them. There are two leads from the brushes, one to the fields and one to the outside circuit. The fields are wound in shunt with the outside circuit. A shunt and separately-excited dynamo is compound-wound, one field coil receiving curreet from the armature, the other from a separate source.

MAGHINE, ELECTROSTATIC INDUCTION. A machine having a rapidly rotating disc of electric substance. A small charge is greatly increased by its inductive action on the disc.

MACHINE, MAGNETO-ELECTRIC.—A machine similar to a dynamo, except that the fields are permanent magnets instead of electro-magnets.

MACHINE, TOEPPLER, HOLTZ.—A changed form of the electrostatic induction machine devised by Holtz.

MAGNET, COMPENSATING.—A magnet placed above a magnetic needle, usually of a galvanometer, so as to counteract the action on said needle of the metal in that vicinity.

MAGNET, CONTROLLING.—A magnet which has control over a certain action: as one attached to a galvanometer to regulate the directive tendency of the magnetic needle.

MAGNET, ELECTRO.— Magnetizable material, usually soft iron, magnetized by surrounding with a coil or insulated wire through which a current of electricity is passed. The wire is called the helix and the iron the core. The electro-magnet loses its magnetism upon the cessation of the magnetizing current.

MAGNET, FIELD.—A magnet employed to produce the field in dynamo-electric machines.

MAGNET, RELAY.—A magnet used in telegraphy to cause a local battery to act at the receiving station. Its coils are connected to the main line.

MAGNET, TABULAR. — Iron-clad horseshoe magnet in which a tube is employed. to increase its liftingpower.

MAGNETISM, AMPERE'S THEORY OF. — A theory advanced by Ampere accounting for the phenomena of magnetism. It assumes the presence of currents in the atoms of matter.

MAGNETISM, ANIMAL. — Sometimes applied to mesmerism, hypnotism and similar manifestations of occult power.

MAGNETISM, EWING'S THEORY OF.—A hypothesis to account for magnetism, advaneed by Prof. Ewing.

MAGNETISM, RESIDUAL. — Magnetism remaining in magnetizable material after it is removed from a magnetizing field is residual magnetism, but the term is restricted to that which remains in soft iron cores of electromagnets after the circuit is broken.

MAGNETISM, TERRESTRIAL.—Magnetism of the earth.

MAGNETITE.—That which, when magnetized, forms lodestone. Magnetic oxide of iron.

MAGNETIZATION.—Causing material to partake of magnetic properties.

MAGNETIZATION, CO-EFFICIENT OF.—A number that represents the strength or intensity of magnetization divided by the magnetizing force **H.**

MAGNETIZATION, INTENSITY OF.—The amount of magnetism present in a magnetizable substance, expressed in magnetic lines of force.

MAGNETOMETER.—A form of reflecting galvanometer, used particularly for measuring the intensity of the earth's field.

MAIN, ELECTRIC.—The most important conductor in any electric distributive system, either of lighting or power.

MANDREL.—A bar, or arbor, usually round, which is driven into work, or on which work is driven, for revolving it in a lathe.

MANGLE-WHEEL.—A gear wheel, the teeth of which are arranged so that the wheel moves back and forth without making a complete revolution.

MANOMETER.—An apparatus used in ascertaining the tension of gases, either in atmospheres or inches of mercury. There are two kinds: mercurial and metallic.

MASS, UNIT OF.—One cubic centimeter of water at 39 degrees F. is the C. G. S. unit of mass.

MATCHER OR MATCHING-MACHINE.—A machine which cuts a groove on one edge of a board and a tongue on the other edge.

MATERIALS, INSULATING.—Substances, usually solids, such as rubber, fiber, mica, etc., which, on account of their high non-conducting properties ase used to insulate electric conductors to prevent leakage.

MECHANICAL, EQUIVALENT OF HEAT.—Number of units of work which, by means of friction or otherwise, will produce one unit of heat. 772 foot-pounds of work are equivalent to one unit of heat.

MEDIUM, ELECTRO-MAGNETIC.—The universal or luminiferous ether through which electro-magnetic waves are propagated.

MEG OR MEGA.—Used as a prefix to mean 1,000,000 times; as, megadyne, 1,000,000 dynes.

MERCURY-GAUGE.—A gauge for measuring pressure of gases by balancing this pressure by a column of mercury in a tube.

MERIDIAN, MAGNETIC.—The magnetic meridian may be regarded as the vertical plane in which a freely suspended magnetic needle comes to rest in the earth's magnetic field.

METALLURGY, ELECTRO.—The science of electrical reduction or treatment of metals.

METER, ELECTRIC.—An instrument for measuring the quantity (or amperes), or the pressure (or voltage) of an electric current.

METRE-MILLIMETRE.—A unit of length for resistances, having a cross-section of one square millimetre and a length of one metre. It may be of any material.

MICRO.—One millionth part, as microvolt, one millionth part of a volt.

MICROMETER.—A small tool, finely graduated, for measuring with accuracy small distances, usually in thousandths or ten-thousandths of an inch.

MICROPHONE.—A device for multiplying the vibrations of sound waves, so as to render a faint or distant sound audible. Used in telephony as transmitters.

MICROTASIMETER.—A device for indicating minute atmospheric changes of temperature and moisture.

MIL.—A unit of length used in measuring the diameter of wires. It is one-thousandth (.001) part of a lineal inch.

MILE, STANDARD.—A standard of resistance employed by Matthiessen. It is 1 mile of copper wire 1-16 inch in diameter at 15.5 degrees C.

MILLI-CALORIE.—The small calorie. Amount of heat necessary to raise one gramme of water from zero to 1 degree C.

MILLING-MACHINE.—A machine in which revolving cutters are used to cut, shape and dress metal.

MITER-JOINT.—A joint whose angle to the plane of the piece it joins is 45 degrees.

MOTOR, ELECTRIC.—A machine for converting electrical into mechanical energy, by passing an electric current through it. The discovery that the armature of a dynamo will rotate when a current is passed through it, was one of the most important in electrical science.

MOTOR, ELECTRIC, ALTERNATING-CURRENT. — An electric motor operated by an alternating current of

electricity. There are two kinds: one being an ordinary alternating current dynamo reversed, the other Tesla's or Thomson's.

MOTOR, PYROMAGNETIC. — A motor operated by pyromagnetism, or the heating of metals, which, when subjected to heat, lose while heated their property of being magnetizable.

MOTOR, SERIES.—A motor wound like a series dynamo, with fields and armature connected in series with the external circuit.

MUD-DRUM.—A drum placed at the lowest part, generally of water tube boilers, to catch sediment, etc.

MULTIPLE-DRILLING MACHINE.—A drilling machine which may carry more than one drilling tool, so that holes of various sizes may be drilled in one piece, without changing drills.

N

NEEDLE, MAGNETIC.—A bar magnet in the form of a needle freely poised so as to permit its magnetic axis to be placed in the magnetic meridian. It is usually poised in the center, on a jewel pivot. Those which move in a horizontal plane are called mariner's, while those which move in a vertical plane are called dip needles.

NEEDLE, MAGNETIC, DECLINATION OF. — The declination or movement of the magnetic needle from the North pole. Its movement is either east or west.

NEEDLE, MAGNETIC, DIPPING OF. — A magnetic needle which moves only in a vertical plane. It is used to ascertain the magnetic inclination, or angle of dip.

NON-CONDUCTORS.— Materials which offer such high resistance to the passage of electricity that it will take some other path of less resistance. They are used as insulators of electric conductors. Rubber, gutta-percha. mica and fibre possess high non-conductive properties.

NUMBER, DIACRITICAL.—The number of ampere turns required to give an iron core half its magnetic saturation.

O

ODONTOGRAPH.—A device used in designing the teeth of gear wheels.

OHM.—The practical unit of electrical resistance. A resistance through which an electric current of one ampere,

or of one coulomb per second, will flow, under a pressure of one volt.

OHM, BOARD OF TRADE (ENGLISH).—The resistance of a column of mercury, 106.3 centimetres in length, having an area of cross-section of one square millimetre at 0 degrees C.

OHM, BRITISH ASSOCIATION. — The resistance of a column of mercury, 104.9 centimetres in length, having an area of cross-section of one square millimetre, a 0 degrees C.

OHM, LEGAL.—The resistance of a column of mercury 106 centimetres in length, having a area of cross section of one square milimetre, at 0 degrees C. or 32 degrees F. Thie is now the international value of the ohm.

OLIVER.—A blacksmith's foot-power hammer, used for forging bolts and nuts.

OSMOSE, ELECTRIC.—A difference in the level of liquids, caused by osmotic action. It takes place when two liquids are separated by a porous diaphragm, and a strong current is caused to flow through the liquid on one side of the diaphragm, into the liquid on the other, the latter rising in level.

P

PANTELEGRAPHY.—A system of fac-simile telegraphy for transmitting diagrams, charts, etc.

PARAMAGNETIC.—Possessing magnetic properties. having high permeability for lines of force: opposed to diamagnetic. Iron is most paramagnetic; nickel, cobalt, manganese and platinum also have these properties. If a bar of paramagnetic substance is suspended near its center and placed in a magnetic field, the longer axis will place itself parallel with the magnetic field, as a piece of wood so suspended in a rapid stream of water would place its longer end parallel to the direction of the current.

PEN, ELECTRIC.—A stylus with a needle oscillated very rapidly within, by means of an electric current, with which a paper is perforated is such a manner as to be used as a stencil for printing a number of copies.

PERMANENCY, ELECTRIC. — The power of electric conductors to retain their conductive properties unchanged regardless of the passing of time.

PERMEABILITY, MAGNETIC.—The degree to which any substance is permeable to lines of magnetic force; its contuctibility of such lines; its property of being the agent of magnetic induction. The permeability of a material, such as a soft iron core, decrease with the rise of the magnetizing force, or, as the saturation increases.

PHONAUTOGRAPH.—An apparatus, working automatically, for the reproduction and registration in visible markings of the vibrations of sound waves.

PHONOZENOGRAPH. — An apparatus for indicating whence a distant sound issues. A microphone, telephone and Wheatstone bridge, connected together, are necessary to operate it.

PHOTOMETER.—Apparatus for the measurement of light given out by any illuminating power or luminous body in standard candle power.

PHOTOPHORE, TROUVÉ'S.—An instrument containing a small incandescent light. Used by physicians in medical examinations in cavities of the body.

PHOTO-TELEGRAPHY. — The reproduction, at a distance, of writing, drawings, pictures, etc., by means of electricity. The most successful is that of Amstutz.

PILLOW-BLOCK (sometimes called Pillar of Plumber's-block)—A pillow or bed that forms the bearing for a shaft, and is made fast to a frame or bed, as the pillow-block of an engine.

PINION.—The smaller of a pair of wheels or train of gears.

PISTON.—A piece, disc-shaped, that closely fits a cylinder bore, as an engine piston, which receives the thrust or pressure of the steam, and is caused to reciprocate.

PITCH-CIRCLES.—The circle in a gear wheel considered its diameter for measurements of speed, etc.; it passes through the point in the tooth where the face meets the flank.

PLANE, PROOF.—A small conductor for the purpose of collecting electricity from bodies charged electrostatically, and of which the measurement is then taken.

PLATE, NEGATIVE. OF ELECTRIC CELL. — The negative element or kathode of a battery. In a storage battery, the plate connected with the negative terminal of the source of charge. In a voltaic cell, the carbon element, which is not attacked by the electrolyte.

PLATE, POSITIVE, OF ELECTRIC CELL.—The positive element or anode of a battery. In a storage battery

the plate connected with the positive terminal of the source of charge. In a voltaic cell, the zinc element, which is attacked by the electrolyte.

PLOW.—The connection from the motor to the current conductor, in underground system of distribution for an electric railway. It corresponds to the trolley.

PLUG, SAFETY.—A bar, wire or plate of fusible metal, which allows a normal passage of electricity, but which fuses, thus breaking the circuit, when an abnormal amount tries to pass.

PLUM-LEVEL.—A tool for determining whether a surface or line is horizontal, consisting principally of a plumb-bob and straight edge.

PLUNGER.—A large cylindrical piston-rod used to cause a displacement in a cylinder by it size alone.

POLARITY, MAGNETIC.—When iron or other magnetizable substance enters a magnetic field it acquires polarity, the South pole being the end at which the magnetic lines enter and from which they flow, and the North pole being the end from which they immerge and toward which they flow.

POLE, NEGATIVE.—The pole or terminal of a battery or dynamo by which the current returns to the generator after flowing through the external circuit. Careful distinction must be made between the positive and negative poles and the positive and negative plates of a voltaic cell. A terminal connected with a positive plate of an electric source (anode) is negative, and the one connected with the negative plate (kathode), is positive. The term "poles" as properly applied to an electric circuit signifies the free ends of a break in such a circuit. When applied to the binding posts of a voltaic cell, the fact should be fixed in the mind that the end which extends down into the electrolyte is the opposite. The negative pole is connected to the positive plate, and the positive pole to the negative plate. In storage batteries this is reversed.

POTENTIAL, UNIT OF ELECTRIC.—The erg. The difference of potential existing between two points which renders necessary the expenditure of one erg of work to force one unit of electricity over the distance between those points, is the the unit difference of potential.

POTENTIOMETER.—A device somewhat on the principle of a Wheatstone bridge for measuring the electromotive force of a battery. A known resistance is placed in opposi-

tion to the difference of potential to be determined, the equality or inequality being shown by the deflection of galvanometer needles.

POWER, CANDLE.—One candle power is the light given out by one standard candle, which is the burning of two grains of sperm candle per minute.

POWER, HORSE, ELECTRIC.—A rate of doing work equivalent to 746 watts per second.

PYROMETER.—A device for measuring temperatures above the range of the ordinary thermometer, ordinarily operated by the expansion of a metal. In Siemens', a platinum wire is exposed to the heat to be measured, its resistance determining the temperature.

R

RAILROAD, ELECTRIC, DEPENDENT SYSTEM.—The current is conductd from the generating station along bare wires above or below the cars and taken off and carried to the motors by means of rolling or sliding contacts. There are three kinds: the overhead, the underground and the surface. In the overhead system the wires are strung directly above the track; in the underground system they are placed in a conduit with an open slot between the rails in which slides the arm which carries off the current; in the surface system, the wire is conducted along the surface of the roadbed and the current taken off by a properly arranged contact.

RAILROAD, ELECTRIC, INDEPENDENT.—A railroad in which the motive power is supplied by primary or storage batteries placed in each car, so that each is independent of the others or of any source of energy other than its own.

RE-EVAPORATION.—The evaporation of any water there may be in a cylinder after the steam is cut off by the heat in the side of the cylinder and piston as the pressure falls.

REFINING OF METALS, ELECTRIC.—The electrolytic refining of metals.

RELAY.—An instrument at the receiving end of a telegraph line. by means of which a local circuit is opened and closed. The impulse which operates the relay may be too weak to operate the receiver, but the local circuit may be of any strength.

RELUCTANCE, MAGNETIC.—A term synonymous with magnetic resistance. The total number of lines or magnetic flux $= \frac{\text{Magnetomotive Force}}{\text{Magnetic Reluctance}}$.

RESISTANCE.—The quality of a conductor of electricity in virtue of which it resists the passage through it of an electric current. To overcome this opposition requires electromotive force. The e. m. f. is converted into heat energy. Resistances are placed in circuits to cut down the e. m. f. or the current.

RESISTANCE UNIT.—Conductor or part thereof through which unit current is obtained by unit e. m. f. Jacobi's is the resistance of 25 ft. of copper wire weighing 345 grains.

REVERSIBILITY OF DYNAMO OR MOTOR.—The ability of a dynamo to run as a motor when supplied with current, or of a motor to run as a dynamo when driven by mechanical power.

RHEOSTAT.—An adjustable resistance; applied usually to a resistance easily varied without opening the circuit, the varying values being known.

ROUTING-MACHINE.—A machine in which a revolving cutter cuts away parts of a surface and leaves other parts in relief; used by engravers particularly.

S

SATURATION, MAGNETIC.—Magnetic substance the intensity of magnetization of which has reached its maximum. The development of the largest possible number of lines of force in the core of an electromagnet.

SCREEN, MAGNETIC.—An iron box or circuit of wire placed over or around a magnet, or other device, to prevent magnetic induction from taking place, or to screen it from external magnetism.

SCRIBING-BLOCK.—A tool, often called a surface gauge, for marking on work the size it is to be when finished.

SECOHM.—A term sometime used instead of henry, the practical unit of self-induction.

SERIES, THERMO-ELECTRIC.—A series of metals arranged with reference to their thermo-electric properties, so that each is electro-positive to any other following it.

SHELL.—The external casing, especially of a steam boiler.

SHELLAC (often spelled Shellack).—A solution applied with a brush, for an insulation and a dialectric; composed largely of resin.

SHELL-REAMER.—A reamer that fits a mandrel; usually coned.

SHUNT.—A connection in parallel with a portion of an electric circuit. An additional path for current. Used also as a verb.

SIDE-CHISEL.—A chisel shaped properly for cutting the walls or sides of keyway slots.

SIDE-TOOL.—A tool for cutting the ends of pieces while being held between the centers of a lathe.

SOLENOID.—An electro-magnetic helix, or cylindrical coil of wire, with a soft iron core. Such an electro-magnet differs from the ordinary, the core being movable, its movements being dependent on the intensity of magnetization.

SOUNDER.—An instrument, used in telegraphy, consisting of an electro-magnet acting on a movable lever. It is operated by a relay.

SPECIFIC HEAT OF A SUBSTANCE.—The ratio of the amount of heat necessary to raise a given weight of a substance one degree in temperature, compared to the amount of heat required to raise the same weight of water one degree.

SPIRAL CUTTER.—A milling cutter whose teeth are cut spirally instead of parallel to the axis of the bore.

SPIRIT LEVEL.—Tool for leveling which employs a bubble in alcohol, held in a slightly curved glass tube, secured in a frame, to indicate a perfectly horizontal position.

SPUR WHEEL.—A gear wheel whose pitch surface is a cylinder.

STATICS, ELECTRO.—The science of electric charges.

STEAM-CHEST.—The chest or box into which steam is admitted before entering the cylinder.

STEAM-GAUGE.—Instrument showing the steam pressure.

STEAM, SATURED.—Steam which is made in contact, or is in contact, with water so that there is no heat in it except the heat of evaporation.

STEAM, SUPERHEATED.—Steam heated away from the presence of water, thus containing more heat than that of evaporation.

STEAM, WET.—Steam containing free particles of water.

SUPER-HEATER.—A sort of secondary boiler, generally placed between the main boiler and chimney through which the steam passes being thus superheated.

SUPPLY, UNIT OF ELECTRIC.—A unit adopted by the English Board of Trade, equal to 1000 amperes for one hour, under pressure of one volt, 1000 watt-hours, or 1.34 horse power for one hour.

SWITCH.—An apparatus by which circuits are opened and closed.

SYNCHRONISM.—The rhythmatic or silmultaneous occurrence of vibrations, pulsations, etc. It is the principle on which the action of certain electrical devices depends.

SYSTEM, THREE-WIRE.—A system invented by Edison, for the distribution of electric current for constant potential service. in which three wires are used instead of two, one being a neutral wire. Two dynamos are employed.

T

TAILINGS.—Errors in the record in automatic telegraphy, due to retardation, or to current flowing after the circuit is broken.

TAPE, INSULATING.—A ribbon in the preparation of which some insulating material is used. It is for winding joints and other exposed places. Rubber tape is used largely.

TREE OR T.—Pipe fitting with two branches at right angles.

TELEGRAPHY, AUTOMATIC.—A system by which a perforated sheet, representing dots and dashes, is caused to automatically transmit the characters represented.

TELEGRAPHY, DUPLEX.—The simultaneous transmission of two messages over one wire in the same direction. Gray's harmonic multiple system is for sending musical notes of various pitch over one wire. For each tone a separate message is transmitted.

TELEPHONE.—A device or combination of devices, for the electric transmission of sounds, especially articulate speech.

TEMPER.—The degree of hardness of steel. It is first heated, then plunged into a cooling bath. Each variety of steel and work requires a different temper.

THERAPEUTICS, ELECTRO, OR ELECTRO-THERAPY.—The use of electricity in the curing of diseases.

THERMOSTAT.—An instrument operated by the expansion of a body by heat, which opens or closes a circuit, thus automatically maintaining a certain temperature.

THERMAL-UNIT.—Amount of heat necessary to raise a pound of water from 39.1 to 40.1 degrees F.

THROW-LINE.—The line described by a part actuated by an eccentric.

TORQUE.—Turning movement of the force exerted on a dynamo armature to rotate it. Torsion around an axis.

TRACTION, MAGNETIC.—The force which tends to keep a magnet in contact with its armature. Must not be confused with magnetic attraction.

TRANSFORMER.—An induction coil used in systems of lighting by alternating current to transform or convert high initial electromotive force to low initial electromotive force such as can be conveniently and safely used for commercial work, or the reverse. The transformer is employed because high voltage currents are transmitted more economically than those of low voltage.

TRANSMITTER, CARBON.—The carbon button transmitter in a telephone.

TRIP-HAMMER.—Hammer whose helve beam is tripped by a cam. It is used mostly in forging.

TROLLEY.— A grooved wheel moving on the overhead conductor of electric railway lines, and receiving from it the current to operate the motor and move the car.

TRUNDLE.—A gear-wheel whose engaging surfaces are rungs instead of teeth, as in a lantern.

TUBES, GEISSLER, GLASS VACUUM. — Tubes of a great variety of forms used to illustrate the luminous effects of electric discharges through gases.

TURN, AMPERE.—The passage of one ampere around a circle, once. A single turn of wire in a coil through which but one ampere passes, sometimes called ampere-winding. The ampere-turns in a coil determine the magneto-motive force of the magnet.

TUYERE.—Nozzle through which air is forced into a cupola, or an ordinary blacksmith's fire, operated with bellows.

TWIN-MILLS.—Milling cutters with teeth on their side faces and circumferences. They are operated in pairs.

U

UNIT, ABSOLUTE.—A unit based upon the centimetre, gramme and second.

UNITS, PRACTICAL.—The volt, ohm, ampere, coulomb, watt and other units. These are multiples of C. G. S. units absolute, which are too small for convenient use.

U. S. STANDARD.—A V-shaped thread with a flat surface at the top and bottom.

V

VACUUM, ABSOLUTE.—A space containing no material substance. The existence of such a space is doubtful.

VALVE-STEM.—The rod connecting the valve with mechanism outside the steam chest.

VIBRATION, PERIOD OF.—The time required for an oscillating body to make a vibration.

VIBRATION, SYMPATHETIC.—Vibration caused in a body by the placing of a vibrating body in its immediate vicinity: as a tuning fork made to sound by placing a vibrating fork near it.

VOLT.—The practical unit of electrical pressure, or electromotive force. The pressure required to move one ampere against a resistance of one ohm. The electromotive force induced in a conductor, usually an armature coil, which is cutting one hundred million magnetic lines (of force) per second.

VOLTMETER.—An instrument for direct reading on a scale the volts or electromotive force in a circuit, or the difference of potential between any two points thereof. They are connected on a shunt to the circle, or in parallel.

W

WALKING-BEAM.—The oscillating beam in the engine of that name to which are attached the connecting rod to the piston on one end, and the connecting rod to the crank on the other.

WATT.—The unit of electric activity or power equal to one joule per second or 10,000,000 ergs per second.

WELDING, ELECTRIC.—Welding metals by the application of electricity. This is done by passing a heavy current through the point of junction at a low e. m. f., or by forming a voltaic arc between the parts to be welded.

WINDING SERIES.—A dynamo or motor field having but one coil which is connected in series with the armature and the outside circuit.

WORK, ELECTRIC.—The joule. One volt-coulomb or one watt for one second.

WORK, UNIT OF.—A unit force acting through a unit distance gives one unit of work. In the C. G. S. system the unit of work is the erg equal to a force of one dyne acting through a distance of one centimetre. The practical unit is the joule = 10,000,000 ergs. The British unit is the foot-pound and is equal to a force of one foot. The ratio between the two systems is: 1 foot-pound = 13,563,000 ergs (about) = 1.3563 joules (about).

Y-Z

YOKE.—A piece that carries or secures two or more other pieces, and adjusts their distance apart. That part of a dynamo frame which connects the limbs of the field magnets.

ZINC, AMALGAMATION OF.—The coating of amalgamation of zinc plates. The amalgam is a combination or alloy. The most important constituent is mercury.

INDIA-RUBBER, TESTS FOR.

India-rubber should not give any sign of superficial cracks on being bent to an angle of 180° after five hours' exposure in a closed air bath to a temperature of 125° Cent.

Rubber containing not more than 50 per cent. by weight of metallic oxides should strech to five times its length without breaking. Pure caoutchouc free from all foreign matter, except the sulphur necessary for its vulcanization, should stretch seven times its length without breaking. The extension measured immediately after rupture should not exceed over 12 per cent. of the original length of the test-piece. The test-pieces should be from 3 to 12 millimetres wide, and not more than 6 millimetres thick and 3 centimetres long. The percentage of ash gives a certain indication of the degree of softness, and may form a basis for the choice between different qualities for certain purposes. Any excess of sulphur over that required for vulcanisation should be removed at the works, and should not appear on the surface of any object.